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TIMBER STAND IMPROVEMENT in the Southern Appalachian Region

DEPARTMENT OF AGRICULTURE FOREST SERVICE

Miscellaneous Publication No. 693

FOREWORD

In the early 1930's when the Civilian Conservation Corps (CCC) was formed, an extensive program of timber stand improvement was begun in the Appalachian region. All available technical information was assembled to guide the timber stand improvement (TSI) work, notably in E. C. W. Forestry Publications Nos. 1 and 2 (1933), U. S. D. A. Technical Bulletin No. 476 (1935), and in later revisions of E. C. W. Forestry Publication No. 2 (1934, 1941). These summarizations pointed out many gaps in existing knowledge. The Forest Service and the Division of Forest Pathology concentrated for the following 10 years on studies to establish a sound basis for stand improvement. Much, too, has been learned through the experiences of those men who, during the CCC program and ensuing years, applied improvement measures in the woods.

This publication brings together the results of research and the experience of TSI practitioners. It is a compilation of published work, processed releases, and unpublished reports by many individuals, and represents little original work on the part of the authors. To promote continuity and easy reading, text references to this voluminous literature have been held to a minimum. The authors have drawn particularly freely from the work of L. I. Barrett, J. H. Buell, L. S. Minckler, A. A. Downs, and E. H. Frothingham, of the Forest Service, and E. R. Roth, of the Division of Forest Pathology in the Bureau of Plant Industry, Soils, and Agricultural Engineering. The appendix section on insect pests was prepared by C. H. Hoffmann and R. A. St. George of the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine.

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Cover photo.—A well-kept forest that will yield high-quality products at a high rate.

WASHINGTON, D. C. AUGUST 1949

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TIMBER STAND IMPROVEMENT IN THE SOUTHERN APPALACHIAN REGION

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INTRODUCTION

Silviculture is an art. The mark of a successful silviculturist is the skill with which he prescribes and applies treatment to each forest stand or to each tree in the stand. Especially important is the skill with which he applies cultural measures to young or intermediate-aged stands. The profit from a harvest cutting depends to a considerable extent on the care given to the trees when they are young.

Since silviculture is a practice applied to living things, its basis cannot be rigid and stereotyped. There are, however, many facts and natural laws to guide every good silviculturist. Timber stand improvement should be considered as an integral part of forest management and not as a job by itself. As will be brought out later, much improvement work can be done as a part of commercial cutting. The silviculturist should consider stand improvement practices continually in connection with harvest cutting and all other management activities.

The operations of timber stand improvement are not ends in themselves and should never be applied unless definitely needed. The requirements of the forest vary from stand to stand and from acre to acre. Variations in site, accessibility, local demands, and other factors will determine how much money a timber owner can profitably spend on stand improvement. Generally speaking, intensive stand improvement practices should be confined to the moist coves and lower and middle slopes where fertile soil and favorable environment produce rapidly growing, desirable species. On the dry, rocky, upper slopes and ridges of the mountains and on badly eroded soils in the Piedmont, conditions are so unfavorable for tree growth that intensive timber stand improvement will seldom pay. Thus any timber stand improvement work thereon must be simple and cheap. The authors have attempted to base their recommendations upon such realities.

The purpose of this publication is to set forth for the technician the best available information to guide him in timber stand improvement in the southern Appalachian region. There are exceptions to practically all rules, but those presented here apply generally in the region.

The variation in desirable timber stand improvement practices results, to a large degree, from wide differences in the physiography, forest soils, climate, and vegetation types of the southern Appalachian region (fig. 1). The Allegheny and Cumberland Mountains to the west

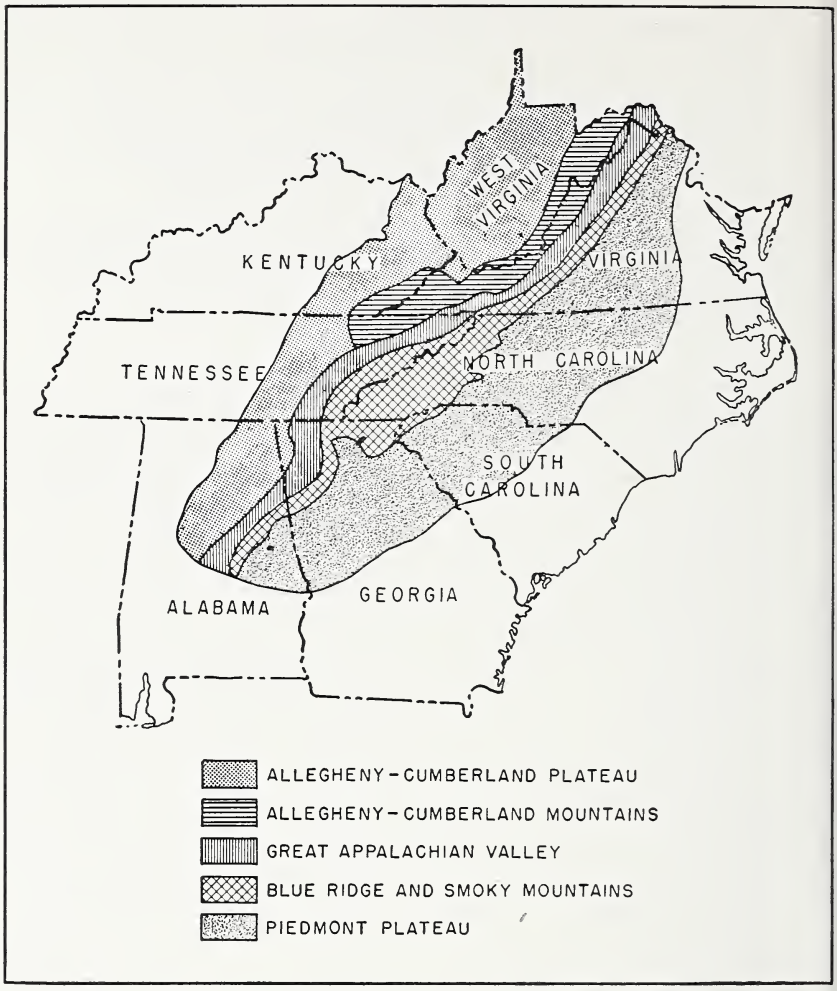

FIGURE 1.—Physiographic provinces of the southern Appalachian region.

and the Blue Ridge and Smoky Mountain ranges to the east are separated by the Great Appalachian Valley province. The Piedmont Plateau to the east and the Allegheny-Cumberland Plateau to the west are broad uplands characterized by considerable variation in forest cover type.

The material presented in this publication is based primarily on studies in the mountain provinces. It can be applied, however, to adjacent valley and plateau provinces with the exceptions noted in the text.

The discussion of timber stand improvement costs is held to a minimum, because it is difficult to be realistic in reporting the cost of each cultural measure. Ordinarily, the silviculturist does not go out

and clean his forest, girdle cull trees, or eliminate vines as separate operations. Rather, he cleans, girdles, thins, and performs the various improvements from spot to spot as the stand requires. Thus, "typical" timber stand improvement costs do not exist. However, a range in probable costs is given in this bulletin as a guide to planning stand improvement programs.

In the sections that follow, the recommended stand improvement practices are given for each major forest type according to primary condition classes—reproduction and saplings, poles, and saw timber. The major types for which practices are presented are (1) the hardwood forest, (2) the pine–hardwood forest, (3) the pine forest, and (4) the spruce–fir forest. Subtypes included under each of these four main headings are listed in the Appendix, page 59.

For a proper understanding of the terms used, the following definitions are helpful:

Cleaning.—A cutting made in a young stand, not past the sapling stage, for the purpose of freeing trees from other individuals of similar age but of less desirable species or form which are overtopping them, or likely to overtop (*50*).[1] Syn. *weeding.*

Improvement cutting.—A cutting made in a stand past the sapling stage for the purpose of improving its composition and character, by removing trees of less desirable species, form, and condition in the main crown canopy (*50*).

Liberation cutting.—A cutting made in a young stand, not past the sapling stage, for the purpose of freeing the young trees from older individuals that are overtopping them (*50*).

Thinning.—A cutting made in an immature stand for the purpose of increasing the rate of growth or improving the form of the trees that remain and increasing the total production of the stand (*50*).

Reinforcement planting.—Planting young trees or sowing seed in partially stocked stands for the purpose of filling in the openings and increasing stand density, or for improving the species composition.

THE HARDWOOD FOREST

The hardwood forest occupies about 57 percent of the forested area in the Appalachian region, as shown in table 1. Except in the Piedmont Plateau it covers more acreage than all other types combined in all provinces. Even in the Piedmont one-third of the forest land is covered by hardwoods. Thus, from an area standpoint at least, the hardwood type is of most importance.

Characteristics of the Hardwood Types

The great variations in site, elevation, and latitude result in a heterogeneous hardwood forest. At least 20 hardwood cover types are found in the region. Most prominent are the oak mixtures of the drier sites in the southern Appalachians, the white oak and yellow-

[1] Italic numbers in parentheses refer to Literature Cited, p. 56.

TABLE 1.—*Total forest area and percent of area by major types and provinces*[1]

Province	Forest area	Forest type			
		Hardwood	Pine–hardwood	Pine	Spruce–fir
	Million acres	*Percent*	*Percent*	*Percent*	*Percent*
Allegheny–Cumberland Plateau.	17.1	67	22	11	0
Allegheny–Cumberland Mountains.	5.5	87	10	2	1
Great Appalachian Valley	6.2	65	25	10	0
Blue Ridge and Smoky Mountains.	7.6	74	16	10	(2)
Piedmont Plateau	22.0	34	30	36	0
All provinces	58.4	57	24	19	(2)

[1] Approximate figures only, determined from Forest Survey reports of the Southeastern Forest Experiment Station, Asheville, N. C., and The Economic Problems of Forestry in the Appalachian Region, by W. A. Duerr. Harvard University Press, Cambridge, Mass., 1949.

[2] Less than 1 percent.

poplar cove stands, and the sugar maple–basswood and red oak–white ash cover types of the northern hardwood belt.

Most of the mountain provinces are covered with a badly deteriorated and culled-over forest, the poorer remnants of once high-quality timber. Recent heavily cut-over areas that have been protected from fire have regenerated to even-aged stands of desirable species in many places. Some of the finest stands of young yellow-poplar have come in on clear-cut areas or abandoned fields in the mountains. The Great Valley and Plateau provinces have a preponderance of second-growth hardwood timber, much of it coppice growth following earlier clear-cutting. Laurel and rhododendron thickets, and bear oak stands at high elevations, completely dominate limited areas.

Fortunately, the desirable species of the Appalachian region have aggressive regenerative powers; and the basis for a rich resource lies in the extensive stands of young timber now so general in the region. Helpful information on how to bring to commercial maturity as many as possible of the better elements of these stands, and how to improve the productivity of the less desirable elements is presented in this publication.

INCREASING THE STOCKING

Young hardwood stands, regardless of cover type, become established readily following cutting or fire. Their quality, species composition, and the form of individual trees are often undesirable, however. Improvement measures should be adapted to each stand on the basis of its condition and origin, and the hazards to which it is subject.

Generally speaking, the young hardwood forest is adequately stocked with trees because of the ready sprouting of most of the species

and the prolific seeding of many such as black locust, yellow-poplar, sweet birch, and red maple. Following the ravages of the chestnut blight, in which about one-third of the total volume of mountain hardwood stands was lost, study showed (*29*) that adequate restocking of large and small openings with desirable species took place promptly. Reinforcement planting is not generally recommended in hardwood stands in view of abundant natural restocking, high cost of planting, and necessity for later release of planted trees.

There may be special instances, however, when stocking can be increased and composition improved by planting yellow-poplar (*33*), white ash, and black walnut. These species require deep, fertile, well-drained soils and abundant light for their best development. They should not be planted on worn-out Piedmont and other plateau soils or on dry, rocky sites in the mountains. Nonrestocking fields or openings 0.1 acre or larger in the forest can be successfully planted if soil and moisture conditions are favorable. Early spring planting is recommended, using 1–0 planting stock, spacing the trees 7 by 7 feet.

Improvement of understocked laurel and rhododendron thickets is discussed on pages 25 and 26.

Cleaning Young Hardwoods

The main objective of cleaning is to favor the best trees by removing strongly competing undesirables. In young, essentially even-aged stands it is often possible to alter effectively the growth advantages of one tree over another so that the best trees have the best chance of being dominants in the ultimate stand. The measures taken to accomplish this are called cleanings or weedings. They are advisable whenever the desirable trees in a stand are being suppressed or injured by less desirable trees, shrubs, or vines, or where the ultimate defect in the stand can be reduced through the recognition of unfavorable stump-sprout conditions, cankers, or other potential defects.

The most effective improvement can be done in stands 5 to 15 years old. Between these ages the stand is well enough established that the composition can be determined, relative growth rates have become obvious, stump-sprout connections and the size of the parent stump can be readily determined, and the elimination of undesirable trees is easy and cheap. Treatment between these ages generally yields no immediate financial return, since the products cut are small. However, in some agricultural areas there is a considerable demand for small stems for such uses as tomato stakes and bean poles.

In general, the so-called crop-tree method of selecting trees for release is a good one. It aims to assure adequate stocking of desirable trees without wasting effort releasing superfluous trees. If a good tree can be freed for maximum growth at intervals of 17 feet, a stand will have at least 150 desirable stems per acre by the time they reach pole size. In practice, intervals of 15 feet to 20 feet are acceptable spacings, depending upon the productiveness of the site. In a young stand, no more trees should be cut than are necessary to favor the desired number. The remaining growth is needed to serve as trainers for good

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form and clear length of the crop trees, for mutual support in ice storms, and as insurance against the loss of the chosen crop trees.

The effectiveness of the crop-tree method of cleaning is well illustrated by Buell (*6*), who reports on the success of CCC timber stand improvement on 28 study areas located in West Virginia, Virginia, North Carolina, South Carolina, Georgia, Kentucky, and Tennessee. Five years after treatment the condition of released crop trees was recorded, and their probable condition at the end of 10 years was estimated. He found that only 14 percent of all released trees had been overtopped or threatened. Illustrative results by species were as follows:

Species:	*Overtopped or threatened—* After 5 years (percent)	After 10 years (percent)
Sugar maple	29	18
White oak	10	30
Chestnut oak	6	14
Yellow-poplar	7	14
All species	14	26

Cleaning accelerates diameter growth materially and height growth to a lesser extent in most species. Buell shows the following comparisons of diameter growth breast high for treated and untreated trees:

Species:	*Diameter growth for the 5 years after treatment, expressed as a percentage increase or decrease of the growth 5 years before treatment* Treated (percent)	Untreated (percent)
Red spruce	+83	—23
White oak	+79	+ 6
Chestnut oak	+46	— 9
Yellow-poplar	+97	— 1
Shortleaf pine	+15	—12
White pine	+63	—16
All species	+54	—10

Downs (*18*) shows actual diameter and height growth for trees released by light and heavy cleaning. His findings are reproduced in table 2.

Costs of cleaning vary widely from acre to acre, depending on the topography, density of cover, number of trees needing release, kind of labor available, and many other factors. Cline (*10*) reported that in New England cleaning hardwoods and pine-hardwood mixtures required from 4 to 12 man-hours per acre for a single weeding, supervision not included. Experience in the National Forests of the southern Appalachian mountains during the CCC and later timber stand improvement programs indicated that cleanings required 1 to 2 man-days per acre. In a combined cleaning and liberation cutting on the Pisgah National Forest in 1931, 73 acres were treated with an average expenditure of 7 man-hours per acre for labor (*2*).

TREES TO FAVOR IN CLEANINGS

The vigor of potential crop trees is important to recognize in making cleanings. Crop trees should be of good or medium vigor because

TABLE 2.—*Cumulative diameter and height growth of hardwoods by crown class–vigor class combinations after release*[1]

DIAMETER GROWTH AT BREAST HEIGHT IN INCHES

Species and treatment	Crown class–vigor class combination					
	Dominant, good vigor	Codominant		Intermediate		Overtopped, poor vigor
		Good vigor	Medium vigor	Medium vigor	Poor vigor	
Sugar maple:						
Not released	0.90	0.66	0.23	0.02	0.06	0.05
Light release	1.59	1.22	.84	.54	.28	.18
Heavy release	1.81	1.48	.97	.71	.46	.28
White oak:						
Not released	1.04	.70	.53	.24	.24	....
Light release	1.16	.91	.88	.44	.36	....
Heavy release	1.24	.88	.90	.58	.45	....
Yellow-poplar:						
Not released	.93	.72	.60	.30	.30	....
Light release	.97	.93	.51	.42	.31	....
Heavy release	1.15	.91	.58	.73	.35	....
HEIGHT GROWTH IN FEET						
Sugar maple:						
Not released	10.5	8.1	3.0	2.1	0.3	0.1
Light release	9.9	9.4	7.0	4.3	3.1	1.2
Heavy release	10.4	10.2	7.0	5.6	3.7	2.6
White oak:						
Not released	8.5	7.0	5.0	3.4	1.6	....
Light release	9.2	6.7	7.9	4.6	3.0	....
Heavy release	9.2	7.9	7.6	5.7	3.0	....
Yellow-poplar:						
Not released	9.9	8.6	7.1	4.3	3.3	....
Light release	9.8	9.3	6.6	5.4	4.3	....
Heavy release	10.7	8.5	5.8	7.3	4.3	....

[1] Yellow-poplar released 6 years, other species 7 years. For dead trees growth was considered zero. In cases of bending or die back below original height, height growth was considered zero, never negative.

poor vigor trees, especially if of intolerant species,[2] respond poorly to release. For example, a yellow-poplar that is growing vigorously but which will ultimately have to compete with trees crowding it from above will continue to grow well only if the overwood is removed while the yellow-poplar is still vigorous. Once a tree of an intolerant species develops a weak crown, it will not respond well to any amount of release. Tolerant species, like sugar maple, often remain quite vigorous even when growing slowly under suppression, and respond readily to release. The average expected cleaning responses of overtopped trees of several important species are as follows:

Good response to release.—Sugar and red maple, beech, basswood, elm, and hemlock.

[2] For tolerance ratings, see Appendix, p. 60.

Fair response to release.—Oaks, hickories, ash, cucumbertree, black walnut, and white pine.

Poor response to release.—Yellow-poplar, birches, black locust, black cherry, and butternut.

Where possible, favor sugar maple, white and northern red oak, ash, basswood, yellow-poplar, black walnut, and cucumbertree. On drier sites, black oak, chestnut oak, or scarlet oak should be favored over post oak or hickories. It is questionable whether cleaning would pay in the improvement obtained in the growth of most other hardwoods. In some areas, however, it may pay to conduct weedings for beech, the birches, black cherry, and some of the other oaks.

The minimum size of a crop tree that should be released depends chiefly on the size of the main stand. In general, it should be at least three-fourths as tall as the surrounding trees. Trees less than 6 feet in height should not be chosen as crop trees, because small trees are difficult to judge for desirability in form, vigor, rate of growth, and possible defects.

If cleanings are done in stands 5 to 15 years of age as recommended, a reasonable upper limit for overtopped crop trees to be released would be about 25 feet in height, or 3 inches in diameter at breast height. These limits are selected because any tree that has suffered suppression until it is 3 inches or more in diameter will probably be of low vigor and unlikely to make a thrifty, rapidly growing crop tree.

Trees that are coarse-branched and have wolf-tree tendencies should not be favored. Quite often these trees are the most vigorous, but they should be removed, nevertheless, to release potentially high-quality individuals.

DEGREES OF RELEASE

The amount of release should vary with the growth energy (tolerance and vigor) of the crop trees and the surrounding weed trees. Release should be *light* for crop trees of high growth energy, not badly overtopped, and surrounded by slow-growing weed trees. Release should be *heavy* for crop trees of low growth energy, badly overtopped, and surrounded by fast-growing weed trees. For *light release*, cut back to a distance of 2 feet from the crown margin of the crop tree all competing vegetation which reaches one-third or more of the way up the crown of the crop tree. Also cut to a distance of 4 feet from the vertical projection of the crown margin of the crop tree all vegetation that is taller than the crop tree (fig. 2). For *heavy release*, cut back for a distance of 4 feet from the margin of the crop tree all competing vegetation which reaches one-third or more of the way up the crown of the crop tree. Also cut for a distance of 8 feet from the vertical projection of the crown margin of the crop tree all vegetation which is taller than the crop tree.

The practice of partial severance and breaking-over at the trunk versus complete severance of trees to be removed in cleanings is debatable. Most evidence shows that trees cut part way through sprout just as vigorously as trees completely cut. Complete severance, moreover, is usually easier.

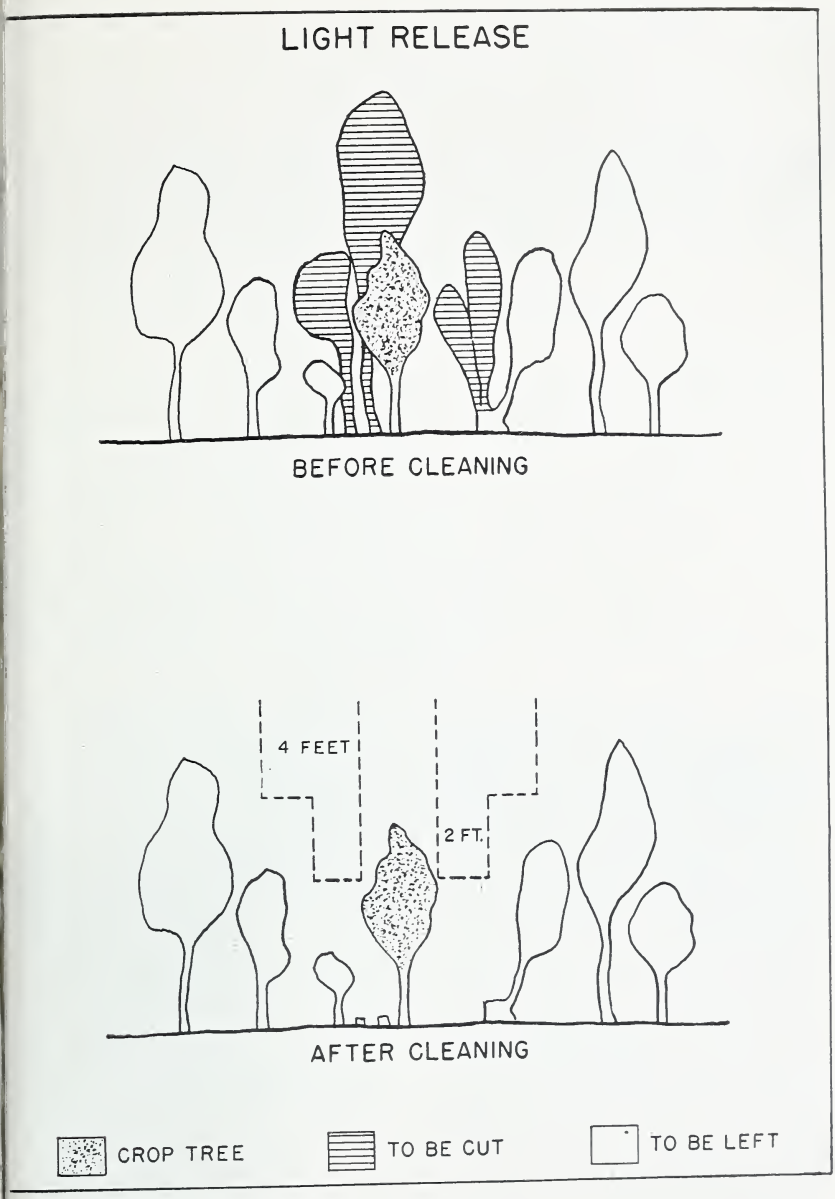

FIGURE 2.—Diagram of light release cutting.

In some past cleaning work, trees to be cut have intentionally been cut high so that sprouts from the tops of the high stumps might serve as trainers for the crop trees. But sprouts from high stumps are usually weak (except for some weed trees like sourwood that

quickly re-attain dominance after cutting). Consequently, the best procedure is to cut at the most convenient height.

DAMAGE AND DISEASE FACTORS IN CLEANINGS

To withstand storm and ice damage, crop trees should be strong, straight, single-stemmed, and sturdy. Spindly, weak trees that are likely to bend after release should not be selected as crop trees. Species such as birches, maples, or others with finely divided branch systems suffer most heavily from glaze damage. Avoid selecting as crop trees species with this branching characteristic, particularly in the vicinity of high gaps where wind and glaze combined are most common. Trees that lean or fork are especially susceptible to ice and snow breakage.

Cattle show a fondness for the succulent growth of some hardwood species, notably yellow-poplar, white ash, and basswood. The cleaning operation usually isolates crop trees and makes them accessible to livestock when dense thickets are opened up. Browse damage can be so serious in areas where the above species predominate that cattle must be excluded if cleaning is to be profitable.

Crop trees should be free of cankers and other defects. Nectria canker occurs widely, particularly on black walnut (fig. 3, *A*), the birches, yellow-poplar, red maple, and basswood. In parts of Maryland and West Virginia the oaks are heavily affected. Trees are occasionally killed by the cankers, but more often they live to produce defective timber. Different species growing on different sites vary greatly in

FIGURE 3.—Common cankers on hardwoods. *A*, Nectria canker on black walnut; *B*, Strumella canker on black oak.

amount of cankering. The great majority of trunk canker infections occur before trees are 25 years old, and trees beyond that age that are free of cankers will likely remain so. No special attempt should be made to cut out cankered trees unless they can be utilized. They should, however, be avoided as crop trees wherever possible. Yellow-poplar will rapidly heal out Nectria cankers if the tree achieves dominance as it passes into the sapling stages. Trunk cankers on black walnut, the oaks, and the birches rarely heal without leaving serious defects. Oaks affected with Strumella canker (fig. 3, *B*) invariably die, break over, or become badly decayed.

Handling Stump-Sprout Stands

Most hardwood species sprout readily after fire or cutting. These sprouts grow rapidly and often form multiple-stemmed clumps which interfere with the establishment of the more desirable seedlings (fig. 4). Seedling sprouts, which are sprouts that originate from severed seedlings, are as good as seedlings if the clumps are thinned to reduce crown competition and to avoid bad stump conditions from developing at the base when the trees become older. Stump sprouts are much less desirable. Oak stump sprouts are very susceptible to decay from the decaying parent stump (*43*); northern hardwood sprouts commonly decay through the large wound left at the base of a sprout when the parent stump rots away. Sugar and red maple,

FIGURE 4.—Multiple-stemmed sprout clumps. *A*, A clump of high, V-crotch sprouts too large for treatment. Removal of one will result in decay of the others. *B*, A pair of low, U-crotch sprouts one of which can be cut without danger of decay to the other.

in addition to being subject to butt rot in stump sprouts as a result of large parent stump wounds, a high origin of sprouts, and dead stubs of companion sprouts, are subject to "blackheart," a degrading discoloration from wounds (*8*).

DESIRABILITY OF EARLY TREATMENT

Sprout stands should be treated before they reach the age of 20 years. This early age treatment permits a better selection of crop trees from the standpoint of attachment to and size of the parent stump, and involves almost no danger of decay from wounds left in cutting companion sprouts. Select crop trees from seedlings, seedling sprouts, or sprout clumps arising from stumps 4 inches or less in diameter whenever possible. Sprouts from larger stumps may be selected if they arise very low on the stump (fig. 5) and if the parent stump wound is small. Since oak sprouts that arise at or below the ground line rarely contract stump decay, while sprouts that arise 2 or more inches up on the stump commonly develop such rot (fig. 6), the low-origin sprouts should be favored by removing the

FIGURE 5.—Sprouts of low and high origin. The large high-origin sprout will probably contract decay from the parent stump, while the low-origin sprouts will remain sound.

FIGURE 6.—This 30-year-old oak sprout developed decay because of its high point of origin on the decaying parent stump. *a*, The decaying butt section of the sprout; *b*, the rotten parent stump; *c*, the point of origin of the sprout on the stump.

higher-origin and often more dominant, companion sprouts (fig. 5). Discriminate against red maple sprouts, because even under favorable conditions they rarely produce acceptable saw timber.

TREATMENT OF OLDER SPROUT STANDS

Where early treatments have been made, a stand will enter the pole size with the crop trees largely single-stemmed. Where there has been no early treatment, pole stands of sprout origin are likely to be made up of sprout groups (fig. 4, *A* and *B*). After companion sprouts, joined at the base with a V-shaped crotch, have grown several inches in diameter, it is usually impossible to remove one without leaving a large wound at the base of the other, through which decay will develop (fig. 7). Twins of this type should be let alone. Where the sprouts have a low, U-shaped crotch between them, however, as in fig. 4, *B*, or are entirely separated from each other above ground, one or more can be removed by any convenient method without

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FIGURE 7.—Oak stump sprout showing decay that developed through the wood exposed when a large companion sprout was removed (left).

much risk of infection to the remaining trees. These recommendations are shown diagrammatically in the lower part of figure 8.

There are some advantages in removing dead or dying companion sprouts in the pole sizes to reduce the deformities and cavities in the butt log that result from the pinching-off or eventual encasement of large dead stubs. There is some question, however, whether this practice would pay for itself unless the wood could be used.

RELEASE FROM OVERHEAD COMPETITION

Many hardwood stands are likely to contain large numbers of highly defective old trees that impede the development of young trees. Frequent ice storms at the higher elevations in the Appalachians, combined with lightning damage, logging damage, and the high natural susceptibility of old beech, yellow birch, chestnut oak, scarlet oak, blackgum, and red maple to serious rot, result in considerable cull on the poor sites. Much growing space at these higher elevations is now occupied by such defective trees. The removal of spreading

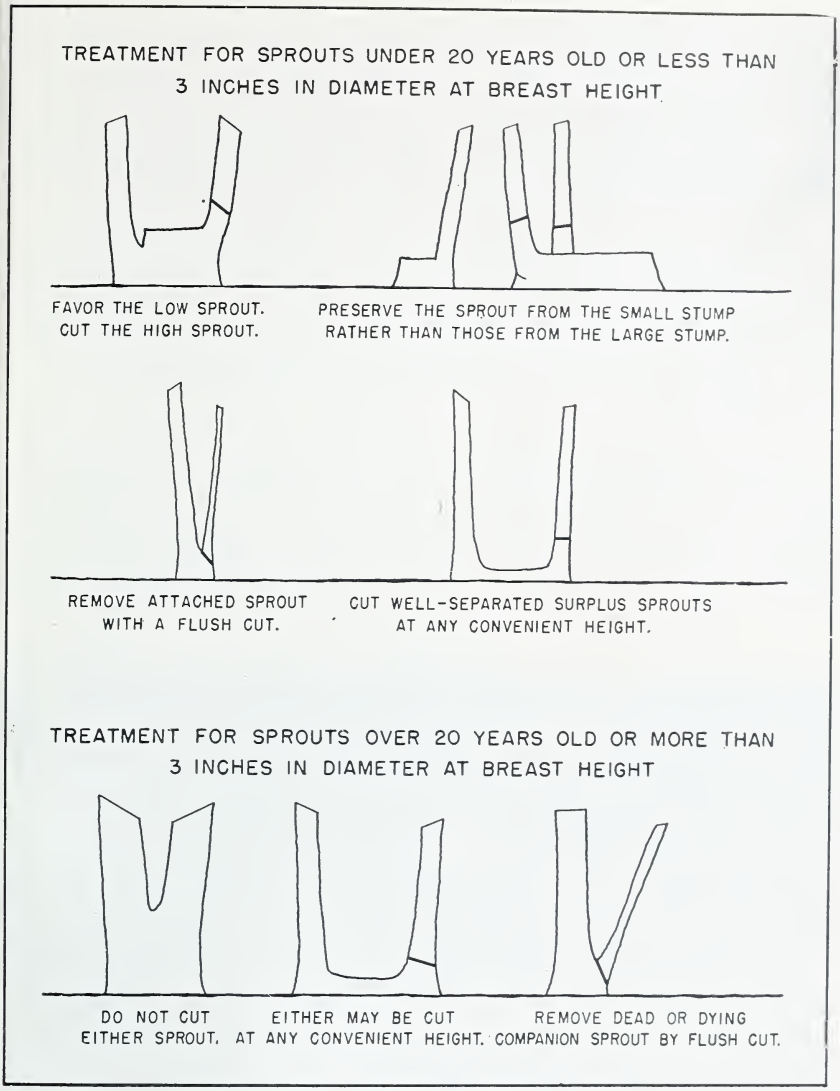

FIGURE 8.—Procedures recommended in handling sprout stands to keep decay at a minimum.

"wolf" trees, bent trees, and rotten culls is a major task in the improvement of young stands under culled-over hardwoods.

The commonest sure signs of serious decay are the hard conks of species of Fomes, the soft, white, long-toothed conks of species of Hydnum, and the soft or leathery conks of species of Polyporus. Wherever practicable, it is well to eliminate conky trees, since their spore-shedding conks provide a continuous source of infection to the

surrounding timber. For hardwoods without conks, signs of major decay are the following: two or more large rotten stubs on the bole or four to five blind knots and large stubs (*25*); large irregular sunken cankers on the oaks caused by *Strumella coryneoidea* (fig. 3, *B*) or *Polyporus hispidus* (*22*); large cankers on maples associated with abortive conks of *Polyporus glomeratus* (*7*); butt wounds more than 12 inches wide (*23*); large broken tops; and open holes in the bole.

Where culls overtop desirable young growth, the advantages of eliminating them are obvious. However, where culls are scattered over a hillside that supports little or no desirable reproduction and is covered with rhododendron and laurel, they should be left until such time as the area is given special treatment to reclaim it from these shrubs. The treatments are discussed on pages 25 and 26.

FELLING AND GIRDLING

Large trees are eliminated generally by felling or girdling and sometimes by poisoning. When a tree gets to be 6 or more inches in diameter, a man can girdle it quicker than he can fell it (*32*, *2*). Studies made about 5 years after the Civilian Conservation Corps stand improvement program (*6*) showed that, although 41 percent of the girdled hardwood trees had broken over, there was little

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FIGURE 9.—An undesirable hold-over tree girdled to make room for better young trees.

damage to surrounding crop trees. The girdling of hollow trees is hazardous, however, since they may break while being girdled or soon after. It is often safer to fell them. Girdling, unless done thoroughly, is also uncertain for some species. Five years after girdling, 66 percent of the beech and 20 percent of the blackgum girdled by the CCC crews on study areas were still alive. Red maple also proved to be tenacious, whereas all completely girdled oaks, involving 8 species, were dead after 5 years.

In girdling, it is important to cut an inch or two into the wood all the way around the tree (fig. 9). Some prefer to cut a wedge-shaped girdle and others prefer to make a double row of deep-slanted cuts, springing each chip well outward. Many girdles have failed to kill, where the axman did not completely cut through the bark on the inrolled callus of large basal wounds.

In recent years, particularly since large stocks of incendiary materials became available following the war, some attention has been given to girdling cull trees by means of fire. Experiments with "goop" —a mixture of jellied petroleum and magnesium powder—have shown that ignition of a smear of the material around the base of large hardwoods sometimes results in death of the tree. The method is not recommended, however, because it is more uncertain and costly than girdling with an ax.

POISONING

Poisoning large trees is cheaper than felling, is more certain to kill than girdling, and results in very little subsequent sprouting (*32, 15*). Silvicides and herbicides are chemicals used to kill trees, shrubs, and herbaceous plants. They act in several ways: As translocation poisons, plant hormones or growth regulators, contact poisons, or soil sterilants.

Poisoning with Inorganic Salts

Sodium arsenite, sodium chlorate, copper sulfate, and zinc chloride have all been used with success in poisoning trees. Although sodium arsenite must be used with great care, it has, in the past, been the most widely used of the tree poisons because of its effectiveness and cheapness.

CAUTION: These compounds are all more or less poisonous and some are combustible on contact with organic materials. Sodium chlorate is explosive in contact with combustible material. Always prepare poisonous solutions out of doors. Even when mixing out of doors it is safer to wear a full facepiece respirator fitted with a filter element designed to eliminate the fumes of the solution being used. Rubber gloves should also be worn and all parts of the body protected. Store stock solutions in locked compartments. Thoroughly clean all vessels used in mixing and applying before putting away or using again. All clothing which may be spattered should be thoroughly cleaned before wearing again.

Evidence is conflicting on the best season of the year to apply poison to trees, and the best season may vary with the poisons used.

Apparently inorganic salt solutions, in the strengths commonly used for poisons, may be effective in killing trees at any season. Subsequent sprouting is reduced, however, if the poison is applied in June or early July, or whenever food reserves in the roots are at a minimum (*5*).

Poison solutions are applied in ax cuts or holes near the base of the tree, following the techniques outlined in the Appendix. Cope and Spaeth (*12*) describe a special tool for chipping the tree and inserting poison in solution all in one operation. This tool is commercially manufactured and reduces labor costs in tree poisoning.

Perhaps the major advantage of poisoning over felling or girdling is the prevention of subsequent sprouting. Sprouting stumps can be effectively killed by application of sodium arsenite (*27*), although sprouting can be more effectively reduced by poisoning the standing tree. To kill a stump, the root collar should be exposed by removing soil and litter. All sprouts should be removed and a frill hacked around the circumference at or slightly below ground level. Poison is applied in the cut from a sprayer or other container.

Sodium arsenite is very effective on oak, ash, hickory, and elm. It is relatively ineffective on sourwood, dogwood, and some of the other species with diffuse porous wood. Repeated application of poison may be necessary in some cases to kill these resistant species.

A detailed description of mixing the poisoning solutions, techniques of application, and precautions required is given in the appendix.

Poisoning with the Newer Silvicides

Many of the newer silvicides fall in the categories of translocation poisons (Ammate) or plant hormones (2,4–D), and are becoming widely used for the control of unwanted vegetation. Although much has yet to be learned about the most satisfactory and economical use of these chemicals, they have already been shown to be useful material for eliminating overhead competition.

Ammonium sulfamate (known by the trade name of Ammate), when placed in a hacked "cup" at the base of a tree, will usually kill it and prevent subsequent sprouting. The cups are made with two downward strokes of an ax, one about 2 inches above the other, with the chip removed. The number of cups required varies with the size of tree, and they should be spaced not more than 6 inches apart around its base. Trees less than 6 inches in diameter at breast height will require 2 cups. Trees 10 to 12 inches in diameter will require at least 5 cups.

One level tablespoonful of Ammate crystals is placed on each cup for trees more than 3 inches in diameter at breast height. One heaping teaspoonful is usually adequate to kill trees less than 3 inches in diameter. The hole-punching ax referred to on page 66 can be used for making a hole which serves as a receptacle to hold the chemical in very small trees. Even better, trees less than 3 inches in diameter may be cut down close to the ground, leaving a V-shaped stump or one with a top shaped like an inverted cone. A heaping teaspoonful of Ammate crystals should be applied to the freshly cut stump immediately.

Ammate seems to be most effective in killing trees when applied in late summer or early fall. It should always be used before leaf fall. The effectiveness of Ammate undoubtedly varies with tree species, but it seems to work well on sweetgum, blackgum, elm, ash, willow, red oak, post oak, pin oak, blackjack oak, water oak, and pine. It acts slower and is less effective on hickory, beech, persimmon, and white oak.

Trees treated with Ammate may leaf out after treatment but will usually die soon thereafter. Unlike sodium arsenite, Ammate is less harmful to animals. Constant contact with Ammate may irritate the skin if it is applied with bare hands. The above recommendations are based largely on the work of Peevy (*39*).

Early in 1948, four different crew organizations were compared in a time study of poisoning trees with Ammate. A crew of three, in which two men chopped cups and one man applied the chemical, was found most efficient. For hardwood trees averaging 8 inches in diameter at breast height, this crew could average 100 cups per man-hour. Approximately 36 trees could be treated per man-hour.

The ammonium and sodium salts of 2,4-Dichlorophenoxyacetic acid (2,4–D) are plant hormones (growth regulators) that will also kill trees if applied as described above, although results to date show them to be slower in action and somewhat less consistent in their killing power than Ammate. They make an effective killing spray for vines and other low vegetation and may be used in very low concentrations. Further discussion of such use may be found on page 20. When commercially prepared compounds are used, the directions and precautions of the manufacturers should be followed. Increased dosages, however, are frequently more effective in killing woody vegetation.

Reducing Vine Competition

On some areas vines, particularly grape and kudzu, do considerable damage by growing through and over the tops of trees. Vine cutting is an important part of stand improvement work over wide areas in the Appalachian region. Five years after the cutting of vines on several areas by the CCC, 40 percent of the vines failed to regenerate, 47 percent grew again but were subordinate to the crop trees, while only 13 percent had grown to an extent that they were again threatening crop trees. Vines should be cut as low as possible, using any convenient method. Once the tree crowns close, the danger of vine damage is slight, except where the vines grow in from adjoining open areas, as has happened during recent years where kudzu has been planted adjacent to timber stands. One trip along the border between the kudzu and the trees, 3 or 4 times during each growing season, with a drag, springtooth harrow, or plow, will prevent the penetration of kudzu into woodland.

Locally, Japanese honeysuckle is a damaging pest. It invades sapling stands from fence rows, road banks, or fields, and kills trees by climbing them and suppressing the crowns. While honeysuckle is not immediately damaging as a ground cover in older stands, it will

often, after a harvest cutting, prevent reproduction from becoming established or smother out small trees.

Honeysuckle can be eradicated by one or two sprayings with a 0.2-percent solution of the ammonium salt of 2,4-Dichlorophenoxyacetic acid (2,4–D), or other forms of the chemical. Since the solution will kill other vegetation, spraying should be timed properly for greatest effect. On areas being given a harvest cut, the concentrations of honeysuckle should be treated before the new generation of tree seedlings appears. In reproduction or sapling stands being invaded by honeysuckle, thorough spraying will kill all vegetation. Toxic effects of 2,4–D disappear from the soil within 2 to 3 months. The area will then have to be planted or revegetated naturally.

Vines high up in trees should be severed. All remaining honeysuckle vines should be thoroughly wetted by the 2,4–D solution. Apply the solution on a hot day at a time when at least 4 hours of sunshine are ensured. If all foliage is thoroughly treated under these conditions, at least 90 percent of the plants will be killed. Some resprouting may necessitate a second treatment the following year.

Back-pack pumps, pressure sprayers, or other commonly available spraying devices are satisfactory for spraying honeysuckle. A device that delivers a fine spray under considerable pressure insures maximum wetting and avoids excessive drip-loss of chemical from the leaves. Equipment should be washed thoroughly if it is to be used later for other purposes, because 2,4–D, even in very low concentrations, is damaging to most vegetation. Spray cans and pumps may be decontaminated by filling with water plus household ammonia (2 teaspoons per gallon of water—4½ quarts per 100 gallons) and letting stand for 24 hours. Then three thorough rinsings of pump, hose, and spray can with water will remove harmful residues of 2,4–D.

Thinning Sapling and Pole Stands

In the Appalachian hardwood types, dense stands of even-aged reproduction are common wherever cutting has been heavy. In preceding sections the handling of these young stands has been discussed, with stress upon the release of strong, healthy crop trees and maintenance in the stand of all other trees not interfering with the development of the crop trees. By the time stands approach 20 to 30 years of age, they may become crowded, particularly in seedling stands of beech, birch, maple, and yellow-poplar, and sprout stands of oak and other hardwoods.

Thinnings in such stands (fig. 10), made so that more crown and root space is given the crop trees, will usually maintain or increase their growth. Because thinning is an expensive measure, it should be done only when the stand requires it or where there is use for the products removed. It does afford an opportunity to give the best trees more growing space, to reduce the number of cankered or malformed trees in a stand, and in stump-sprout stands to promote the growth of the more desirable sprouts. Thinning may sometimes increase the total growth of wood per acre and will always result in putting a larger proportion of the increment on the crop trees. For

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FIGURE 10.—A stand of young hardwoods in need of thinning which will (1) remove crooked, poorly formed trees, (2) remove less desirable species, and (3) improve the spacing.

example, Hough and Taylor (*26*) found that a 40-year-old stand of northern hardwoods grew at a rate of 1.02 cords per acre when unthinned. A similar stand from which 38 percent of the basal area had been cut in 1933 grew 1.73 cords per acre per year during the next 10 years.

MINIMUM THINNING REQUIREMENTS

Where intensive forest management is practiced, as on well-managed farm woodlands, repeated thinnings may be desirable, based upon various systems. In this publication on stand improvement, however, thinnings are discussed only in connection with maintaining reasonably high productivity and quality and not from the standpoint of obtaining maximum yield through frequent intensive treat-

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ments. For instance, under average Appalachian hardwood conditions, one thinning made when the dominant and codominant trees are between 5 and 8 inches in diameter at breast height will be sufficient to bring most stands into good growing condition. It must be kept in mind that thinning should be done only when the stand requires it or when the thinnings can be profitably sold.

Heavily stocked stands result in clean-boled trees, yielding relatively knot-free timber. Thus, full stocking should be maintained unless there is a tendency for most of the trees in the stand to grow at about the same rate and become stagnated. This sometimes happens, especially in dense stands of oak, maple, or beech. By the time undue crowding begins to affect growth adversely, a stand is usually old enough to yield products of value from thinnings. A considerable volume of fuel wood, pulpwood, chemical wood, mine props, and posts is produced in the Appalachian region from thinnings in sprout stands.

STANDARDS FOR THINNING[3]

In yellow-poplar, dominance is asserted early, and thinning is rarely advisable until the stands pass 20 years. After this age thinnings can advantageously be made to increase crown space for the best trees, and the material removed will be large enough at least for pulpwood. The removal of surplus trees at such an age is not so likely to result in the production of abundant epicormic branches (or water sprouts as they are sometimes called) of the kind that follows the opening of younger stands of yellow-poplar and white oak. To keep yellow-poplar stands thrifty but still well stocked, the per acre basal areas, numbers of trees, and spacings shown in table 3 are desirable for the dominant trees 5 inches or larger in diameter at breast height.

Mixed oak stands generally tend to be less well stocked than yellow-poplar. Because of the slower growth rates of oaks, thinnings are usually not required until the thirtieth year or later to keep the stand vigorous and the tree crowns full and healthy. Favorable stand densities per acre to be used as a guide to thinning mixed oak stands for average site conditions are given in table 3.

Improving Saw-Timber Stands

Stand improvement operations in second-growth and old-growth timber with the intention of benefiting a saw-timber stand should be confined to cases where much of the cut volume can be utilized. The girdling and poisoning of large trees for the purpose of accelerating the growth of other trees already of sawlog size is expensive and unlikely to pay. Usually, trees of sawlog size will not respond markedly to thinning. When an area has been logged, the subsequent elimination of defective trees is an important form of stand improve-

[3] The standards for thinning suggested in this publication are intended as general guides to be modified as local circumstances require. For example, a superior site, good markets, and easy accessibility might indicate lighter and more frequent thinning than recommended here.

TABLE 3.—*Average stocking figures for thinning in yellow-poplar and oak stands with different average tree diameters (trees 5 inches d.b.h. and up)*[1]

Type and average diameter breast high (inches)	Basal area per acre	Trees per acre	Spacing of trees
	Square feet	*Number*	*Feet*
Yellow-poplar:			
6	85	390	10 × 11
8	110	295	12 × 12
10	120	200	14 × 15
Mixed oak:			
6	70	320	11 × 12
7	80	265	13 × 13
8	90	230	14 × 14

[1] These data are based on preliminary results from 25 study plots on the Fernow Experimental Forest in West Virginia, where five intensities of thinning in pure stands of young yellow-poplar are being compared. Additional unpublished information from sample plots on the Bent Creek Experimental Forest and observation on the Pisgah National Forest, N. C., further substantiate the recommendations given.

ment, but it is aimed at the release of younger timber and has already been discussed.

Partial cutting in merchantable stands to favor high quality species and trees of good form is actually harvest cutting and therefore outside the scope of this publication. Removal of saw-timber trees solely because of poor form could not often be justified unless the material removed could be disposed of profitably. As far as possible, all large trees should be cut in the course of a harvest operation. If wolf trees, defectives, and conky trees shedding spores of heart rot fungi are bypassed by loggers, they should be cut or killed as soon after logging as possible. In this way the damage done when they fall will be at a minimum and little or no interference with the growth and health of the new stand will result.

Appalachian and northern hardwood saw timber is subject to damage by many agents, especially in exposed situations. Ice breakage is probably the major cause of top rot, and fire is the major cause of butt rot. Partial cutting results in some logging damage, and lightning, cankers, and various other injuries open the trees to heart rot infection. Large damaged trees should be marked for removal during the next cut on managed forests. Thus the timber owner can salvage them while decay is at a minimum, and he will not have to eliminate them later as culls from stands of advanced reproduction.

PRUNING

The objective of pruning is to keep the knotty core of the tree as small as possible so that the maximum of clear lumber can be produced from the butt log. Pruning, in spite of its advantages, is of questionable value among most hardwoods, especially the northern species which grow slowly and which, at the pruning wounds, tend to develop Nectria cankers, insect activity, and discolorations running well into the wood.

CONDITIONS UNDER WHICH PRUNING MAY PAY

Most Appalachian hardwoods self-prune adequately when grown in closed stands, particularly yellow-poplar, ash, northern red oak, and basswood. Some, notably scarlet oak, retain side limbs for a great many years, even after the limbs die. The following are some of the conditions under which it may pay to prune hardwoods: (1) Where high-value species suitable for veneer, such as white oak and black walnut, are growing on good sites and are readily accessible, (2) when an abundant supply of cheap labor is available, and (3) in a species such as scarlet oak where pruning can make the difference between a low-grade butt log riddled with loose knots, small cavities, or rot pockets, and a clear butt log that will often bring the same price as higher grade red and black oaks.

There are great advantages in pruning while the trees are small, preferably between 3 and 4 inches in diameter breast high. The smaller the knotty core, the better. Studies among the oaks have shown that it takes about 10 years for most wounds up to 2 inches wide to heal (*42*). Thus clear wood will not begin to be laid on until about 10 years after pruning. Considering the fact that slabbing will take off some of the clear wood when the tree is harvested, it becomes obvious that pruning must be done early if it is to accomplish its aim of providing wide boards and timbers of clear wood.

METHODS OF PRUNING

Pruning can be done any time of year and should be confined to the better crop trees, probably not more than 50 or 60 per acre. Late winter or early spring pruning will result in the least bark stripping consistent with quick callusing. In the oaks, studies have shown that pruning wounds should not exceed 1.5 inches in width or considerable rot may develop at the wounds. In a study of 351 oak pruning wounds in Virginia, Roth (*42*) found that behind 15 percent of the wounds over 1½ inches wide active decay was in progress 10 years after pruning. There was no decay, however, in wounds originally less than 1½ inches wide. Pruning of white oak in open or thinned stands is of doubtful value, since water sprouts develop profusely on the boles after pruning. Sugar maple also tends to feather out profusely after pruning but the branches remain small and soon die.

In pruning dead branches, a flush cut should be made through the callus at the base of the branch to promote rapid healing. In removing live branches, a flush cut should be made and care taken not to strip the bark below the cut. The danger of stripping when removing large, heavy branches is lessened if a 6-inch stub is left in making the cut. A second, flush cut will then remove the stub. A ladder and handsaw have proved the most convenient equipment for hardwood pruning. Small trees can be pruned in two stages, the first 8 feet in one operation, and the next 10 feet about 10 years later. Part of the live crown can be cut into without materially affecting growth, but the danger of feathering is greater under these conditions.

Conversion of Laurel, Rhododendron, and Bear Oak Thickets

Laurel and rhododendron thickets cover an estimated one and one-half million acres in the southern Appalachians and in some local areas are so dense that tree seedlings cannot establish themselves. These thickets often occupy excellent timber-growing areas, although laurel tends to be most troublesome on the drier slopes and ridges.

White pine, which is quite adaptable to a wide variety of sites, will become established and keep ahead of resprouting laurel and rhododendron when planted in lanes or cleared spots. Width of lanes cut for planting should be at least three-fourths the height of the thicket. Diameter of spots should be equal to the height of the thicket. For thickets of various heights the cutting rule will work about as follows:

Thickets 1–5 feet high.—Cut lanes 2 or 3 feet wide, spaced 6 feet from center to center, and plant trees 6 feet apart in center of lanes. This will provide about 1,200 trees per acre. Spots spaced 6 by 6 feet and equal in width to height of the thicket may be more economical for thickets not over 3 feet high.

Thickets 6–10 feet high.—Cut lanes 5 to 7 feet wide, spaced about 12 feet from center to center and plant trees 4 feet apart in center of lanes. This will give about 900 trees per acre, and natural pruning will result from the close spacing along the row and the competition of the thicket between the rows. Circular spots should be as wide as the height of the thicket and spaced 12 by 12 feet from center to center with 2 trees planted per spot, or a total of about 600 trees per acre. Use of spots would probably be preferable at the lower range of height, but in 10-foot thickets, strips probably would be cheaper and more successful.

Thickets 11–20 feet high.—Cut lanes 9 to 15 feet wide, spaced about 18 feet from center to center. In each lane plant 2 rows of trees 4 feet apart with 6 feet between trees in the rows. This arrangement will give about 800 trees per acre. Circular spots 18 feet from center to center can be used to advantage only if the thicket is not more than about 14 feet, as heights much above this would require virtual clear-cutting. Probably the best arrangement for planted trees in such cleared spots is in the form of a 4-foot equilateral triangle with a tree at each apex.

Costs for establishing white pine in laurel thickets as described vary with the conditions encountered. A 12-acre area on the Bent Creek Experimental Forest, near Asheville, N. C., was planted in 1945, requiring 6 man-days per acre for clearing lanes and 1 man-day per acre for planting about 400 pines. The brush averaged about 8 feet in height.

Any area where an accidental burn is severe enough to kill thickets back to the ground can be successfully planted to white pine. If planting is done between the time of the burn and the start of the next growing season, the trees will outstrip the sprouts. Spacing should be about 6 by 6 feet. Intentional burning of laurel or rhododendron thickets ahead of planting is not recommended because the

intense fire required to kill the shrubs back to the ground would be extremely risky and difficult to confine to a desired area. Furthermore, even in the densest thickets some desirable hardwood young growth may be present. This scattering of good stems forms a valuable mixture with white pine.

On the driest slopes and ridges shortleaf pine (below 3,000 feet elevation) or pitch pine may be substituted for white pine in converting laurel thickets. Because these species are less tolerant and slower growing than white pine, the width of cleared lanes and spots should be increased by one-fourth. In their early years plantings of these pines should be watched and given release if the brush closes in before they gain dominance.

Dense patches of bear oak occur to a limited extent along the summit of the Blue Ridge and other areas. Little is known about the reclamation of these wastelands. Usually such brushy areas are protection forests not capable of producing timber species. Attempts to convert them to more desirable growth will in all probability be unprofitable.

THE PINE–HARDWOOD FOREST

White pine–hardwood and yellow pine–hardwood types comprise 24 percent of the forested area in the Appalachian region (table 1). White pine–hardwoods are confined almost entirely to the mountain provinces, while yellow pine–hardwoods occur to the greatest extent in the Piedmont and Allegheny–Cumberland Plateau sections. Pine–hardwood types, of which there are six subtypes, contain more than 25 percent but less than 75 percent of pine by volume.

Characteristics of Pine–Hardwood Types

White pine mixed with upland hardwoods, such as the oaks, red maple, and yellow-poplar, occurs in the mountains on moist sites above 2,000 feet. White pine grows well in mixture with hardwoods and in this region reaches its best development in the high rainfall belt of the extreme southern Appalachian Mountains and in the Blue Ridge section of Virginia and North Carolina.

As the name implies, the yellow pine–hardwood type consists of yellow pines mixed with upland hardwoods, primarily oaks. Forests of this type are found on moderately dry to very dry soils throughout the Piedmont and other plateau provinces and in the mountains below 3,000 feet. At the lower elevations and in the mountain valleys, shortleaf and Virginia pine are commonly mixed with hardwoods. Pitch and Table-Mountain pine and hardwood mixtures occupy the higher slopes and dry ridges. In the Piedmont, from the Blue Ridge Range to the beginning of the Coastal Plain, Virginia, shortleaf, and loblolly pines occur in mixture with hardwoods in successive bands in the order given. Loblolly pine forms a more prominent part of the mixed stands in the central Georgia Piedmont.

Because growth rates of pine are superior to those of most hardwoods on the poorer sites, and the wood has a greater variety of uses,

the intent of management is usually to increase the proportion of pine. This policy is primarily dictated by present industrial demand rather than normal ecological succession. Silviculturally it is far easier to grow hardwoods than to perpetuate pine. In fact, hardwoods are definitely encroaching on pine stands in much of the Piedmont region, particularly in the shortleaf pine type (*4*), largely because of their aggressive sprouting habit on cut- or burned-over lands.

Increasing the Stocking

Like hardwood forests, pine–hardwood stands are generally well stocked but often contain defective trees or undesirable species. When these undesirables are eliminated by liberation cutting, girdling, or poisoning, large openings result. In these openings soil preparation is advisable to increase amounts of reproduction of the better species, particularly pine.

If large seed trees are present in the stand, pine or light-seeded yellow-poplar come in well in openings on a mineral soil seedbed. Removal of litter and scarification of soil by machine or by hand result in improved stocking. Seed spots should be prepared in the late summer before seed falls. If the work is done by hand, litter should be raked from 3-foot strips separated by 3-foot unraked strips. The mineral soil should be chopped or loosened slightly. A Council fire tool is suitable for the entire operation. A light tractor and disc harrow will scarify soil and disturb the litter sufficiently to encourage seeding in of pine. The larger openings in one 25-acre cutover area in North Carolina were scarified at a cost of $1.28 per acre by means of a light tractor dragging a butt log with stump attached. Per hour costs included the tractor at $2.50, driver at $1, and scout at $0.75. Five percent of the area was actually scarified. On many areas the soil is disturbed sufficiently by tractors in the normal course of logging, so that no special treatment is necessary.

Litter removal and scarification by hand is costly and should be done only in natural or created openings 0.1 acre in size or larger. Even then, release of young pines (see p. 28) may later be necessary on good hardwood soils supporting aggressive hardwood sprouts. The number of such openings per acre to be scarified will depend on the amount of liberation cutting being done.

Although burning creates a favorable seedbed for pine and yellow-poplar, the use of fire is not recommended because of the expense and risks inherent in it. The damage done by widespread burning in the Appalachian region to remove litter is likely to exceed the benefits, even where the fire intensity and area burned are under control.

Planting pine in 0.1-acre openings is a satisfactory method of improving stocking. In the Piedmont, within the range of loblolly pine, this species does especially well as a stand reinforcer because of its rapid juvenile growth. Planted shortleaf pine also does well in much of the Piedmont and on the south slopes of the southern mountains. However, until more is known about the susceptibility of planted shortleaf pine to littleleaf, this species should not be planted in sections of the Piedmont where littleleaf is severe. The

planting of white pine on suitable sites is practical. Because of its greater tolerance, it will grow in mixture with hardwoods in spots as small as 20 feet in diameter. The planting of hardwoods is generally not recommended on the drier sites common in the yellow pine–hardwood region.

Cleaning Pine–Hardwood Stands

CLEANING YOUNG YELLOW PINE–HARDWOODS

The yellow pines are frequently associated with fast-growing sprouts of low-grade hardwoods, such as the poorer oaks, hickories, blackgum, and red maple. Where the pines are not successfully competing with these hardwoods, the pine should be released on the crop-tree basis of about one good tree every 15 to 17 feet. If this is done, there is a good chance that the released trees will attain dominance. Buell (*6*) found that only 8 percent of 184 shortleaf pine crop trees were overtopped or threatened after 5 years. Twenty-seven percent of 236 white pines were not successfully competing with the growth of adjacent hardwoods.

In judging the degree of release necessary, the silviculturist must anticipate the relative height growth of the pine and adjacent hardwoods. If the pine is heavily suppressed and weak in vigor, it will require at least 5 years to attain the normal height growth rate of about 2 feet per year. Consequently, hardwoods must be cut back so severely that they will not overtop the pine before 5 years. If the pine is still growing 1 to 2 feet in height per year and has a moderately vigorous crown, release can be relatively light. This general rule of thumb can be followed: For yellow pines 2 to 5 feet tall, cut back competing hardwoods within a distance of 3 feet of the stem; for pine 6 feet or more tall, cut back competing hardwoods that are at least two-thirds the height of the pine and that are within a distance of 6 feet of its main stem. This rule, the results of which are illustrated in figure 11, should be varied in application to allow for variations in vigor of the pine and height and vigor of the hardwoods.

No more trees should be cut than necessary to assure the dominance of the pine. Understory or noncompeting trees are particularly necessary to minimize the limbiness of pine. As many as possible of the desirable hardwoods such as white, black, and northern red oak, yellow-poplar, ash, black locust, and dogwood should be left in the stands. Not only is their wood sometimes as valuable, or often even more valuable than pine, but a heavy admixture of hardwood leaf litter greatly improves soil fertility and water relations, especially in the heavier soils of the Piedmont.

Virginia pine is the limbiest of the yellow pines and should be grown in dense stands. Rarely would it pay or be otherwise advantageous to weed in Virginia pine–hardwood stands. Loblolly pine is inclined to have large limbs if open grown, and plenty of trainers should be left around the trees. Shortleaf pine responds well to release unless it has been heavily suppressed and is of poor vigor.

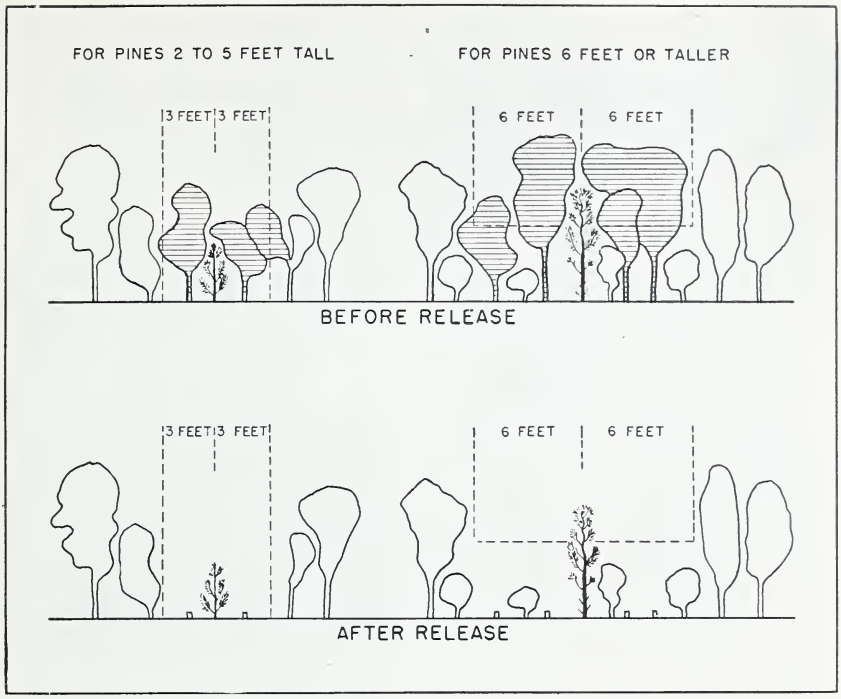

FIGURE 11.—Guide for releasing young yellow pines in mixture with hardwoods.

On areas where the littleleaf disease is active, shortleaf pine should be discriminated against in cleaning, in favor of the less-susceptible loblolly pine and the better hardwoods. In certain sections the rust canker caused by *Cronartium fusiforme* (fig. 12, *B*) is common on loblolly. Stem-cankered pines should not be released as crop trees, but cutting them as a sanitation measure is unlikely to have much effect and is not recommended. It is better to try to maintain a high density in cankered stands, since this results in relatively early death of many cankered limbs before the cankers spread to the trunks. Littleleaf and fusiform rust are described and discussed further on page 67 of the Appendix.

CLEANING IN WHITE PINE—HARDWOODS

The hardwoods associated with white pine are generally of much better quality than those mixed with the yellow pines: and white pine–hardwood sites are usually much more productive. Thrifty young white pine responds well to cleaning. White pine will ordinarily grow as fast as the most rapidly growing associated species, except vigorous sprouts. The cleanings should be on a crop-tree basis, leaving all vegetation not threatening to overtop the pine, because white pine is inclined to be very limby, and closely associated hardwoods tend to keep the pine side branches small and short-lived. Overcutting

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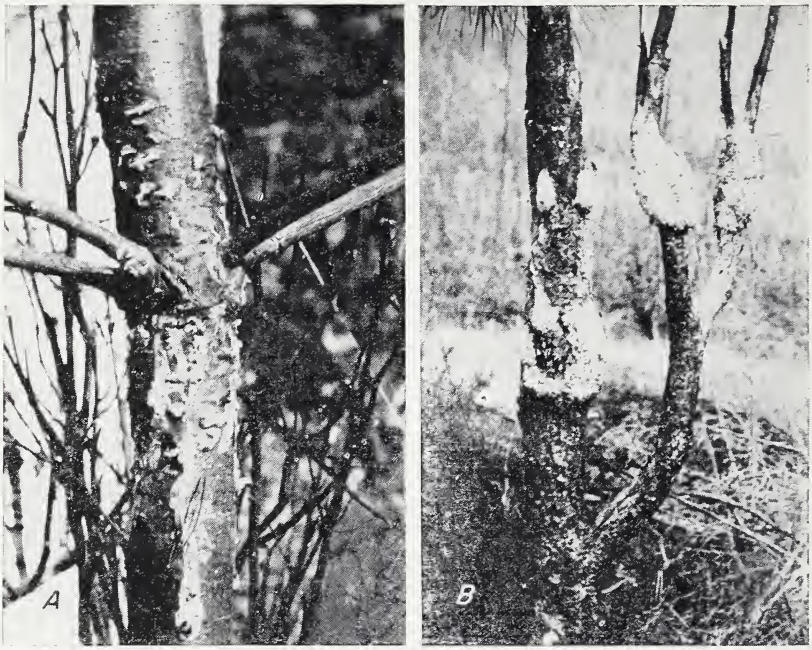

FIGURE 12.—Rust cankers on pine. *A*, Blister rust canker on white pine. *B*, Fusiform rust cankers on loblolly pine.

can be worse than no cleaning, but judicious release of selected trees can pay good dividends. As an example of this response, the removal of a continuous cover of young birch overstory from white pine in one set of experiments increased diameter growth from 75 to 200 percent (*11*).

The white pine weevil can be very damaging in pure pine stands, but a hardwood admixture generally lessens weeviling. Heavy weeding, however, greatly increases attack by the weevil. Selective release on a crop-tree basis will provide the best growth rate commensurate with a minimum of weevil damage. White pines bearing blister rust cankers (fig. 12, *A*) should be removed in cleaning operations only if undamaged trees can be released thereby.

Cleaning costs vary as do other costs, depending on the particular features of each job. Hawley (*20*) found that white pine crop trees on the Yale Forest near Keene, New Hampshire, could be released with about one-quarter to 1 man-day of work per acre.

Release from Overhead Competition

Many young pine stands suffer from the competition of old-growth cull hardwoods and to a lesser extent from scattered overstory pines. The overtopping hardwoods should be eliminated as early as possible by felling, girdling, or poisoning, and competing vines should be cut. The growth rate of the released trees will thus be accelerated.

In the case of young white pine liberated from a hardwood overstory, Downs (*15*) reported that in northern Georgia released pines grew 3 to 8 feet more in height in 9 years than similar unreleased trees. The mortality caused by falling limbs and snags was only 2 percent on the treated area as compared to 0.5 percent on the untreated area.

It is not always wise to eliminate scattered old pines, because they constitute a valuable seed source if the young stand is understocked or should be killed by fire. Old pines with conks of *Fomes pini* (fig. 13, *B*), should, however, be removed because they constitute a rot hazard to the young stand. Pines that appear to be congenitally crooked or limby, that is, those whose bad form cannot be accounted for by environmental factors, should not be left as seed trees because their progeny may have bad form. Old seed trees with heavy infections of *Cronartium fusiforme* should also be eliminated because their progeny probably inherit a susceptibility to this disease.

Liberation of young white pine is particularly fruitful. Largely because of the good fire protection of the past 20 years, white pine is coming in under many decadent hardwood stands. Removal of cull trees has been found highly beneficial to the white pines, which will quickly accelerate height growth and form a desirable component of the stand.

Pines girdled in the fall or winter are less likely to serve as brood trees for damaging local attacks by bark beetles than those girdled in late spring or summer, and poisoning with sodium arsenite discourages bark beetle attack of the treated trees at any season.

FIGURE 13.—Conks of heart rot fungi. *A*, Conks of *Fomes rimosus* on black locust. *B*, Conk of *Fomes* (*Trametes*) *pini* on shortleaf pine.

Other chemicals have also been successfully used in conjunction with girdling, to minimize subsequent bark beetle attack.

Detailed methods of eliminating overtopping hardwoods by felling, girdling, or poisoning were discussed on pages 16 to 19.

Thinning Sapling and Pole Stands

Thinnings made in pine–hardwood stands of cordwood size prevent the pine from being crowded out by fast-growing hardwoods and at the same time produce salable or usable wood from the stand. Thus the thinning becomes in part an improvement measure and in part a commercial cut. Where pine is clearly being outgrown by low-grade hardwoods, spot thinning on a crop-tree basis will often be justified even where the thinnings cut cannot be used.

THINNING IN YELLOW PINE–HARDWOODS

In thinning to favor yellow pines, it must be remembered that suppressed trees of these species do not respond well to release. A badly suppressed pine with a weak crown will require 5 years or more to rebuild its crown and attain an average growth rate. The ratio of crown length to total tree height for pine should not be allowed to drop below 30 percent. Pines with short, weak crowns may never attain dominance in a mixed stand even though released by a heavy thinning. Loblolly and Virginia pine are more tolerant than shortleaf, pitch, and Table-Mountain pine, and can compete with hardwoods on nearly even terms if their crowns are good.

The best stocking for optimum growth varies widely, depending on the site. For instance, the infertile and impoverished soils on some parts of the Piedmont can sustain fewer trees per acre than the fertile slopes of some mountain lands. Stocking figures discussed here do not necessarily represent the most desirable conditions for maximum volume or quality production. Rather, they indicate a level of stocking that will insure good growth and the general health of the stand. The following data, which are averages for trees 5 inches in diameter breast high or larger, on an acre basis, may be used as guides for basal areas, number of trees, and spacing.

Average d.b.h. (inches):	*Basal area (square feet)*	*Trees (number)*	*Spacing (feet)*
6	70	325	11 × 12
7	85	280	12 × 13
8	95	250	13 × 13

These data are based on unpublished records for thrifty stands in Virginia and North Carolina, growing on a variety of sites. Stand compositions varied from about 25 to 60 percent pine mixed with miscellaneous oaks and other hardwoods.

THINNING IN WHITE PINE–HARDWOODS

The major differences between thinning in white pine–hardwoods and yellow pine–hardwoods are that (1) the hardwoods associated

with white pines are likely to be more desirable species and therefore need not be so heavily discriminated against, and (2) white pine is more likely to compete successfully with hardwoods in height growth than are the yellow pines on their respective sites. Mixed pine–hardwood composition is desirable for optimum soil fertility and water relations. Therefore, a strong hardwood component should be retained where species and form are good and where the hardwoods do not interfere with the better pines.

Since white pine–hardwood mixtures usually occur on the better sites, the above thinning standards for yellow pine–hardwoods should be increased 10 to 15 percent when being applied to white pine–hardwood mixtures. The greater the proportion of white pine, the greater the stocking can be.

Improving Saw-Timber Stands

Measures to improve saw-timber pine–hardwood stands should be taken in connection with a harvest cut if possible. The cost of cutting, girdling, or poisoning worthless trees can be partly or entirely offset if some return is realized on the rest of the operation. The best method of treating stands containing many wolf or cull trees is to make what is commonly called an improvement cut. This is a commercial cut designed to rid the stand of the poorest trees, which are marketed for whatever they will bring. After such a cut is made, any residual culls can be girdled or poisoned.

Eastern and southern logging practice in pine generally involves harvesting the trees when they are under 70 years old and not long after they have reached sawlog size. Thus stand improvement measures taken in stands made up of trees already large enough to cut cannot be expected to influence greatly growth or composition within the merchantable stand left. The elimination of undesirable residual hold-overs for the benefit of the new stand has been discussed on pages 30 to 32. Trees to eliminate in the older pine–hardwood stands include particularly those bearing conks of heart rot fungi, spreading wolf trees, limby or rough trees, and culls as defined on page 31.

Pruning

Hardwoods greatly help the pines to self-prune. It is questionable whether it would ordinarily be necessary or profitable to prune the yellow pines, where they are associated with abundant hardwoods. Some pruning of white pine mixed with hardwoods may well be worth while, however, because of this tree's characteristic retention of dead side branches. Pruning of these small dead branches will greatly reduce the length of loose knots in the butt log. The methods for pruning pine are discussed on pages 42 to 45, and for hardwoods on pages 23 and 24.

THE PINE FOREST

Occupying 19 percent of the total forest area in the Appalachian region, the pine types are of great commercial importance, especially

in the Piedmont province, where 36 percent of the timberland is in essentially pure pine (table 1). There are eight pine cover types recognized in the Appalachian region (Appendix, p. 59).

Pine Types and Their Characteristics

White pine usually occurs in mixture with hardwoods. Pure white pine occupies a limited acreage, and at elevations above 2,000 feet on moist slopes it reaches its best development.

Pure stands of shortleaf, Virginia, and pitch pine occur in the mountain valleys on south slopes, and throughout the Allegheny–Cumberland Plateau province. East of the Blue Ridge there are successive north-south bands of Virginia, shortleaf, and loblolly pine types. Loblolly pine is limited to a fringe of Piedmont counties in Virginia but widens southward to occupy a major part of the Georgia Piedmont.

Eighty percent of the yellow pine stands are of old-field origin, are even-aged, but contain understory hardwoods. In the mountains occasionally stands of pitch and Table-Mountain pine with a minor mixture of hardwoods occur on dry ridges.

Increasing the Stocking

For greatest volume production and best form, young pine stands should be well stocked. Often old fields are sparsely restocked where adjacent seed sources are inadequate. Under these conditions the scattered young pines become bushy with heavy limbs that persist and cause large knots that will lower the quality of lumber.

If understocked conditions are remedied early, satisfactory stands can be produced. Interplanting understocked spots is a highly successful way to improve the density of reproduction. The yellow pine species, preferably loblolly in the Piedmont and shortleaf in the remainder of the region, should be planted as 1–0 planting stock. On fertile sites in the mountains, white pine sometimes seeds in old fields. Where stocking is poor, similar reinforcement measures may be used with 2–0 white pine stock.

In filling in the unstocked openings, trees should be spaced 6 by 6 feet. If interplanting is completed within 5 years after field abandonment, little trouble will be experienced later with poorly formed trees that would have resulted from understocking. However, once spreading "cabbage" pines are established, interplanting will not eliminate them. If more than one-fourth of the area is occupied by these large-crowned young pines, they had better be cut and young trees planted on the entire area.

It should be remembered that the yellow pines, which grow best on abandoned farm lands, are intolerant species that require full sunlight for optimum development. Reinforcement planting cannot be delayed, therefore, until the natural trees attain sapling size and close in the principal openings. Four years of study on the Lee Experimental Forest in Virginia indicate the following rule of thumb to guide reinforcement planting. For loblolly pine, plant in openings at least as wide as the adjacent trees are tall. Shortleaf pine needs half again as

much room. Thus, if advance reproduction is 10 feet tall, loblolly pine would not be planted in any opening narrower than 10 feet, or shortleaf pine in openings less than 15 feet wide.

The planting of hardwood species is not recommended unless the topsoil (A-horizon) is at least 8 to 12 inches deep. Yellow-poplar is a good species to plant under these conditions. It is intolerant, however, and has space requirements like loblolly pine. Minckler and Chapman (*36*) give detailed specifications of the soil-site requirements for planting hardwoods.

Cleaning Young Pine Stands

Since pine stands are composed primarily of one major species there is less need for early cleanings in pine than in mixed stands. The principles suggested for cleaning in pine–hardwood types on pages 28 to 30 apply generally to pure pine stands. Cleanings should be made on a crop-tree basis and cutting restricted to removal of undesirables interfering with selected trees. Occasional good hardwoods can be favored in spots where the pine is inferior.

In cleanings throughout most of the Piedmont, loblolly pine should be favored over shortleaf pine because it is much less susceptible to the littleleaf disease. In the northern Piedmont of Virginia or in other areas where the littleleaf disease is absent, shortleaf pine may be favored over Virginia pine. In the mountains, where littleleaf does not occur, shortleaf pine should be considered superior to pitch and Table–Mountain pines and the poorer hardwoods.

Special cleanings may be advisable in damaged stands to bring through as crop trees those least injured. Major causes of such damage are ice and snow, shoot moths, sawflies, white pine weevil, and cankers. (See appendix sections on diseases and insects.)

Thinning Sapling and Pole Stands

Because of the commercial demand for pine pulpwood, early commercial thinnings are feasible in most pure pine stands. Five or six inches in diameter breast high is about the minimum size for a tree to be marketable as pulpwood. Thinning in stands of smaller trees tends to increase the size and prolong the life of side branches, particularly in limby species like Virginia and shortleaf pine. Therefore, thinning in very young stands is generally not recommended, except where glaze storms are common (see pp. 38 and 39). If overstocked young stands are beginning to stagnate, they should be thinned lightly.

Costs of thinning depend on tree height and diameter, topography, efficiency of labor, and to a lesser extent on volume cut per acre. Downs (*14*) found that it takes 3.25 man-hours for workers to produce a 160-cubic-foot unit of 5-foot loblolly pine pulpwood from 13-inch trees, but 4.25 hours if the trees were 6 inches in diameter. Ordinarily one man can fell, buck, and pile from 1 to 2 cords of pulpwood per day when thinning pine stands.

Thinning in pine, as in other types, offers an excellent chance to remove diseased, crowded, or malformed stems. Frequent thinnings permit the highest cultural development of the stand, but maximum

volume production requires a high level of stocking. It is not the purpose of this publication to discuss the comparative returns from different numbers and intervals of thinnings. Rather, thinning is discussed here only from the viewpoint of maintaining reasonably well-stocked, thrifty stands. Guides for desirable stocking are given in table 4. In general, pine tree crowns are good indicators of the

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FIGURE 14.—A young dense stand of old-field loblolly pine which should be thinned to improve quality and spacing. Early selection of the best crop trees is essential for quality timber production.

TABLE 4.—*Average stocking figures for thinning in pure pine stands with different average tree diameters (trees 4 inches d.b.h. and up)*[1]

Type of average diameter breast high (inches)	Basal area per acre	Trees per acre	Spacing of trees
	Square feet	*Number*	*Feet*
White pine:			
6	115	500	9 × 10
8	125	300	12 × 12
10	125	175	16 × 16
Loblolly pine:			
6	75	360	11 × 11
8	85	220	14 × 14
10	85	140	17 × 18
Shortleaf and pitch pine:			
6	80	375	10 × 12
8	85	230	14 × 14
10	90	150	17 × 17
Virginia pine:			
6	75	360	11 × 11
8	80	210	14 × 15

[1] Based on the following: For white pine, Frothingham (*19*); for loblolly pine, Chapman (*9*); for all species, stand tables from temporary plots in the Carolinas and Virginia.

necessity for thinning. If the live crown length is less than one-third of the total tree height and the side branches of adjacent trees are interlaced, thinning is needed (fig. 14).

SPACING GUIDES

Useful rules of thumb to guide spacing in thinning practice have usually been based on some arbitrary function of diameter. In the "D plus 4" rule, crop trees are spaced at a distance in feet equal to diameter plus 4. The "D times a factor" rules give consistent levels of basal area stocking regardless of the average diameter of the stand (fig. 15). The "D plus" rules result in overstocking when the trees are large, and understocking when the trees are small.

The recommended rule of thumb for the spacing of crop trees in pure pine stands is D × 1.75. For example, in stands of 8-inch trees, spacing would be 14 feet (8 × 1.75). This spacing provides 77.5 square feet, which closely approximates the 80 square feet of basal area per acre considered to be a fair average for most pine types. It will be noted in figure 15 that when the trees in a stand average about 5 inches, the D + 4 rule gives the same results as the D × 1.75 rule. Likewise, when the average diameter is 8 inches, the D + 6 rule is the same as the D × 1.75 rule.

The space between the crowns of adjacent trees can be used as a further guide to spacing. If the branches of adjacent dominant trees are interlaced or touch one another, thinning has probably not been heavy enough. Adequate space between tree crowns should be provided to allow for lateral expansion. The forester should estimate the rate at

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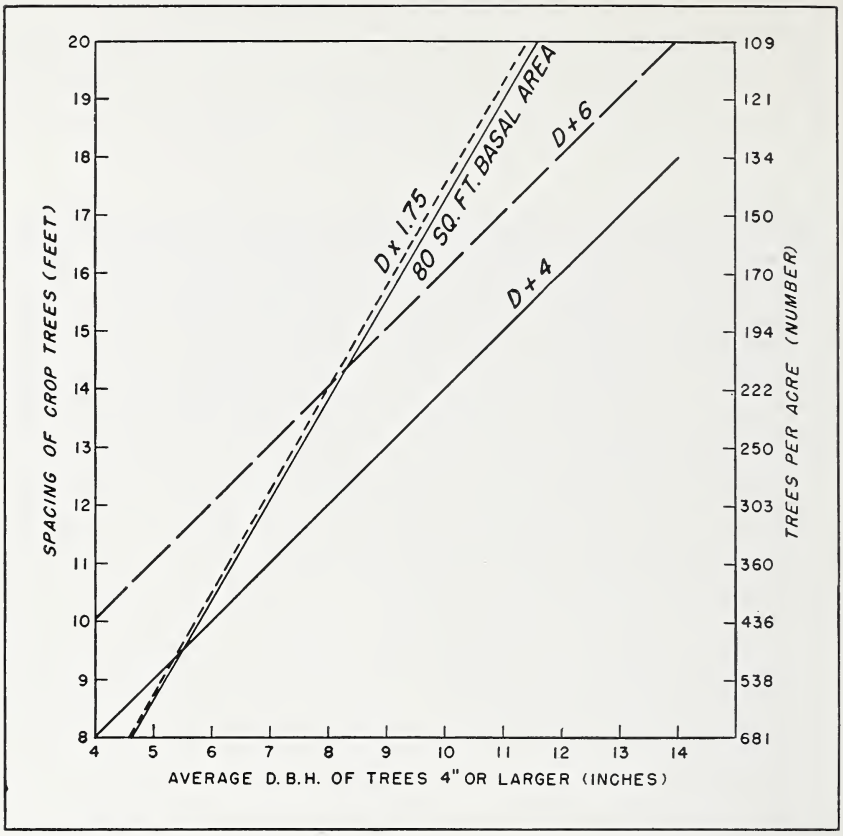

FIGURE 15.—Rules of thumb for spacing, as compared to basal area. (Adapted from Averell (*3*).)

which tree crowns will close in from two directions and space the dominant crowns so that they will have room to expand without major interference until the next thinning operation.

Rules of thumb should be used only as *guides to* spacing. They do not serve as marking rules. Decision on what trees to cut or leave must be made in the field, where considerations of form, crown, and defects may be weighed.

MINIMIZING GLAZE DAMAGE

Glaze is a layer of ice formed when rain, sometimes supercooled, freezes on objects whose temperature is at or slightly below the freezing point of water. Although glaze storms are damaging to hardwoods, they are particularly disastrous to pine stands that have been recently thinned. In most parts of the Appalachian region, ice storms are frequent enough to be a controlling factor in the management of pine stands. Downs (*16*) reports that in the Piedmont, for example, serious

glaze storms occur on an average of once in 10 years. Their intensity and extent are variable and spotty.

In pine, ice damage may consist of bending, uprooting, or bole breakage. Branch breakage in pine is minor compared to that in hardwoods. Pine up to 12 feet in height may be bent severely but many of these trees will straighten with but minor crooks. Severe bending occurs in size classes 2 to 5 inches d.b.h. and heavy bole breakage takes place in the 6- to 10-inch-size classes. Top breakage due to ice is probably the biggest factor leading to trunk decay in the Appalachian region (*41*).

In formerly dense stands of 6- to 10-inch-diameter trees that have been thinned, glaze storms can cause serious uprooting and breakage because the residual trees are tall and slender. Thinning in such stands is undesirable. Uncrowded stands with sturdy, large-crowned trees withstand ice damage fairly well.

Thinning at the right time can be a great aid to developing stocky trees that will resist ice damage. Thinning too late or too little may be worse than none, even disastrous. Young dense stands should be thinned early—when the average tree diameter is as low as 2 inches. When trees become tall, slender, and small-topped, it is too late to thin to prevent ice damage, and the stands had best be left intact.

To summarize the thinning rules designed to minimize glaze damage:

1. Dense stands averaging 6 inches d.b.h. or less should be thinned as soon as possible. If very dense, thin lightly at first, and more heavily later.

2. Dense stands averaging more than 6 inches d.b.h. may be thinned moderately.

3. Do not thin, in the hope of improving the stand or its growth rate, any dense stand averaging more than 6 inches d.b.h. in which the trees are tall, slender, small-topped, and weak. There is a strong likelihood that natural losses other than glaze damage would more than balance any gain due to increased growth; and with lessened mutual support and protection, these weak trees would be all the more susceptible to storm damage. These stands may be held for further increment and then clear cut, leaving seed trees. If no weather-firm trees are available for seed trees, planting is necessary.

4. Do not leave any weak trees for future growth in any system of partial cuttings. Leave only sturdy individuals, able to stand alone.

Release from Overhead Competition

Pure stands of young pine are likely to have a scattered overstory of old-growth pine or hardwoods, often in the form of "wolf" trees (fig. 16). The methods of handling such stands are the same as those discussed for pine–hardwood types on pages 30 to 32. Hold-over cull hardwoods should be eliminated as early as possible (fig. 17). However, sufficient pines should be left as long as a seed source is required or advisable. This may be until the new stand is fully stocked and past the age when fire might wipe it out. There is no evidence that susceptibility to decay is strongly hereditary, and therefore rotten

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FIGURE 16.—Girdling of this "wolf" tree many years ago would have increased the yield of the surrounding pine stand by making more growing space available.

culls may be left as seed sources until the young stand reaches infective age, which normally is about 20 years.

Where there are insufficient residual hold-overs to make a commercial cut, the conky trees, other culls, and the crooked or excessively

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FIGURE 17.—Thrifty pines growing up through the dead crown of a hardwood "wolf" tree, girdled when the pines were small. Note how the tree crowns are well spaced without any large unused opening.

limby trees should be cut, girdled, or poisoned (see pp. 16 to 19). In parts of the Piedmont where the littleleaf disease is severe, leave a maximum of loblolly pine seed trees and a minimum of shortleaf. In the mountains and in those sections of the Piedmont where littleleaf is not a factor, shortleaf pine should be encouraged.

Virginia pine, while limby, is a good pulping species and is a valuable crop along the foothills of the mountains and along many of the broader valleys of the mountain region. A few seed trees of this species will generally stock an area satisfactorily, and residual trees should not be cut until this reseeding has taken place.

Improving Saw-Timber Stands

Where a pine stand is well managed, it should not be in need of much improvement by the time it reaches saw-timber size. The time to improve pine stands is in their early years, and the job is facilitated by the ready market for pine in small sizes. The importance of stand improvement measures in older timber is further minimized by the nearness of such stands to the time of harvest.

One of the profitable improvement measures in saw-timber pine is a light salvage cut that anticipates mortality. Rough, limby trees can often be removed at a profit and with a benefit to the stand. Improvement cuts can also remove lightning-damaged pines, bark-beetle infested trees, or those with red heart or other diseases and injuries. Removal of trees with conks and cankers will reduce sources of fungus infection to other residual trees. Removal or killing of cull hardwoods will improve the conditions for pine reproduction at the time when the harvest cut is made. On easily accessible areas and with good markets, such improvement cuts may be made frequently, and almost any time the situation requires. Under less suitable conditions a saw-timber stand that needs improvement may receive only one such cut before the harvest cut, with some good growing stock being taken along with the rough and cull material to make an operable volume.

Perhaps the greatest opportunity for the improvement of old-growth pine stands is the salvaging before they die of shortleaf pines affected by the littleleaf disease. This operation is generally conducted as a commercial cut. The necessity for the early recognition and salvage of littleleaf trees is forcefully indicated by plot records from severe littleleaf areas. Over a 5-year period all severely affected trees died of littleleaf, 57 percent of the moderately affected trees, and 22 percent of the dominant and codominant trees that appeared healthy and normal when the plots were established. Littleleaf is primarily a problem in other phases of forest management (*24*), rather than in stand improvement. However, wherever littleleaf is doing important damage, timber stand improvement should be used to favor the less-susceptible associated pines and the better hardwoods.

Pruning

Good results are obtained in pine stands where fast-growing, selected crop trees will produce much higher quality lumber when the lower branches are removed. The decision to prune must be based on the value added by pruning in relation to cost. Some species, like white pine, do not prune well naturally (fig. 18). Others, like loblolly pine, develop large, persistent limbs unless the stands are dense.

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FIGURE 18.—A white pine plantation ready for pruning on a crop-tree basis. It will produce very low quality lumber if not pruned soon.

BRANCH PRUNING

As soon as crop trees can be definitely chosen in young stands, the pruning operation should begin. Probably not more than 100 or 125 of the best-formed and disease-free trees per acre should be pruned. Trees should preferably be 3 to 5 inches d.b.h. Pruning is not likely to pay unless the selected trees are allowed to lay on clear wood for 30 to 50 years. Two-inch pine knots require 5 to 8 years to heal, and about 2 inches of clear wood may be lost in slabs when the logs are sawn. To gain clear boards of reasonable width, at least 30 years' growth is necessary.

Early pruning is cheapest because the limbs are then small, and it keeps the knotty core to minimum size. If pruning is begun before the trees are about 25 feet tall, however, removal of limbs to clear a 16-foot butt log (17 feet from ground to top) will require two operations. White pine can stand removal of the lower 30 to 35 percent of live crown without its growth being retarded (*17*). For the yellow pines, a live crown equal in length to one-third of the tree height must be retained—all other live crown below this may be removed in pruning.

Pruning in two operations has several advantages. First, the central knotty core is reduced in size, since the first half-log can be pruned

earlier than the section above it. Also, the first pruning can be made to a height of 8 feet, which a man can readily reach, and the next pruning by ladder or with a pole saw can clear the first log. These two operations, which require different equipment, can economically be separated.

Loblolly pines with branch cankers of the fusiform rust should not be selected for pruning if the cankers are within 6 inches of the main stem, because the stem is likely to be infected already. Limbs with cankers 6 inches or more from the bole can be pruned without danger of later stem infection from this source. Many white pines infected with blister rust can be saved by removing branch infections that might later become lethal trunk infections. The removal of diseased branches will prevent trunk infection, provided the yellowish bark indicating the edge of the canker is 4 inches or more from the trunk (*34*). The characteristics of rust cankers are described in the Appendix.

Some pruners prefer pole extensions on saws, and others prefer pruning shears. Most, however, find that hand saws and ladders do the best job and are most convenient to use. It is more difficult to make flush cuts with shears than with saws. Care should be taken to prevent bark stripping, especially when pruning is done in the spring and summer.

Pruning costs vary with many factors such as height of pruning, size of limbs, tree species, tools, and labor. About 12 acres of shortleaf pine were pruned on a crop-tree basis in 1948 on the Bent Creek Experimental Forest at a cost of 7 cents per tree. Trees averaging 6 inches d.b.h. were pruned with a pole saw to a height of 17 feet. Labor was paid 60 cents per hour. Hawley and Lutz (*21*) estimate that pruning white pine to 17 feet, 100 trees per acre, will cost 11 cents per tree. Southern Appalachian experience indicates that it takes 10 minutes to prune a white pine 9 feet.

BUD PRUNING

A discussion of pruning pine trees would not be complete without mention of bud pruning, although it is still in the experimental stage. Bud pruning consists of removing all lateral buds on young pine trees as they develop, so that only one branchless leader is produced, usually to the height of one 16-foot log. The method is best adapted to species that produce one branch whorl per year, such as white pine.

The forester who intends to bud prune should start when pine trees are about 3 feet high. He should leave two or three whorls of the lowest branches to sustain tree growth. As soon as buds form (after height growth has terminated in June or July), he should pinch off the lateral buds surrounding the terminal bud, carefully avoiding damage to the one terminal bud. Small lateral branchlets may develop from stem leaf fascicles so that at the time of the next de-budding, small clippers will be necessary to remove these branchlets. In species like loblolly pine that produce laterals two or three times a season, pruning of shoots as well as de-budding will be necessary unless the trees are bud pruned promptly each time lateral buds develop. As with branch-pruned trees, bud-pruned trees should be selected on a crop-tree basis, about 100 to 125 trees per acre being treated.

The principal advantages (*13*) of bud pruning are (1) it produces completely knot-free boles, (2) less time is required to grow clear wood, and (3) the danger of fungus infection is reduced. Disadvantages of bud pruning are (1) it is very risky if leaders are likely to be damaged by insects, animals, or weather, (2) the few whorls of branches left at the tree base tend to grow vigorously to produce a "candelabra" effect, and (3) costs are likely to exceed those of branch pruning.

Early experience indicates that both height and diameter growth of bud-pruned pines are as good as for unpruned trees. Until more is known about probable damage from all sources and the costs of bud pruning, the method should be carefully studied before being widely adopted as a substitute for branch pruning.

THE SPRUCE–FIR FOREST

Originally occupying more than 1 million acres along the crest of the Allegheny–Cumberland Mountains and the Great Smokies, the spruce–fir forest has been reduced to a fragment of its former area. Only about 60,000 acres now support spruce and fir, although much denuded cut-over and burned land is suitable for growing these and associated species. The type occurs above elevations of 3,500 feet in the Allegheny–Cumberland Mountains and above 4,500 feet in the Great Smokies. Red spruce and Fraser fir are the characteristic species with an admixture of yellow birch, sweet birch, sugar maple, black cherry, American beech, and other species becoming increasingly abundant at the lower fringes of the type.

The planting and release treatments outlined require heavy investments per acre. The alternative on thousands of acres of devastated spruce land, however, is a near-worthless stand of birch, maple, and pin cherry for 500 to 1,000 years or such time as nature will require for the slow reestablishment of spruce and fir. Reforesting of these barren lands may be speeded by the establishment of plantations in blocks, which thus break up wide treeless expanses with future seed-producing stands.

Increasing the Stocking

After the cutting and burning of the original forest, the great majority of spruce-fir lands went over to dense growths of defective, brushy hardwoods or herbaceous growth. Some remained barren. The important problem in such areas is to build back a desirable growing stock. This can be accomplished through planting or direct seeding.

On the three types of areas needing restocking—brushy hardwood, dense herbaceous, or barren rocky conditions—red spruce, Fraser fir, Norway spruce, or red pine can be grown. Fraser fir, which is not a good timber tree, and Norway spruce, an introduced species, should not be planted if red spruce or red pine stock is available. On dry exposed sites, 2–0 or 2–1 red pine should be planted. Release will ordinarily not be necessary. The following guides should govern planting of red spruce.

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FIGURE 19.—If spruce is planted in such dense cover of bracken fern and blackberry as this, it must be released during the first growing season.

PLANTING UNDER DENSE, HERBACEOUS, AND SHRUBBY VEGETATION

Many former spruce sites with shallow, peaty soil and moderately wet conditions are covered with dense blackberry vines, ferns, low shrubs, or weeds, which shade 90 percent or more of the ground (fig. 19). To establish successful plantations on these sites, 2–1 or 2–2 red spruce stock should be used.

If the shade density[4] of shrubby and herbaceous cover is more than 75 percent, release is imperative in late June or early July of the first growing season. Where the shade density under blackberry vines, ferns, and other low shrubby cover is 75 percent or less, release is not necessary. Where herbaceous vegetation is extremely dense, as on some creek bottoms where the soil is deep, release will be necessary at least the first, third, and fifth years after planting. Release is accomplished

[4] "Shade density" is the percentage of light checked by the crowns, assuming unbroken light to have a value of 100 percent. Thus, a shade density of 75 percent indicates that 75 percent of the light has been checked by vegetation, and 25 percent is passing through.

by cutting low, competing vegetation for a radius of 1½ to 2 feet around each tree.

Minckler (*35*) reports that these treatments on sites with dense cover resulted in the establishment of 59 and 72 percent of planted spruce seedlings after 3 years in North Carolina and West Virginia, respectively. Height growth of seedlings on released plots was 50 to 100 percent greater during the second and third years than growth on check plots.

Prescribed burning before planting, or burning followed by 2 or 3 years of grazing, is an effective method of reducing density of herbaceous and shrubby vegetation. Because of the excessive damage that can be done to the soil organic matter by improper use of fire, burning is not recommended except under conditions where fire intensity is certain to be light. Burning should be done only under the direct supervision of an experienced man. Planting within 2 or 3 years after accidental burns is recommended.

"Premium-grade" planting stock, selected on the basis of stem diameter and root-crown balance,[5] will insure a somewhat better chance for success on sites where vegetation is particularly dense.

PLANTING UNDER A YOUNG STAND OF BRUSHY HARDWOODS

The vegetation on many sites is composed of scrubby pin cherry, red maple, deciduous holly, sassafras, sumac, rhododendron, and yellow birch, with a shade density of 70 percent or more (fig. 20). Successful plantations can be established under these conditions only if proper measures are taken to release the trees after they are established.

Minckler (*35*) gives the following tentative recommendations for releasing planted spruce in dense brushy hardwood stands: In stands of high density, where pin cherry is 20 to 40 feet tall with a dense undergrowth of blackberries, plant red spruce and release it the first and third summers, cutting in June or July to minimize vigor of sprouting. Two subsequent releases, timed to remove encroaching hardwoods, will be necessary. In stands of medium density, where red maple, pin cherry, yellow birch, and other species are 15 to 30 feet tall, release the first and fifth summers. One additional release will be required. In stands of low density, where pin cherry, red maple, and other hardwoods are 5 to 20 feet tall, one release between the first and fifth year is necessary. It should be timed to keep young spruce vigorous and not suppressed.

Release is accomplished by cutting openings 10 to 12 feet in diameter in the canopy of heavy stands and 5- to 7-foot openings in medium- or low-density stands.

PLANTING ON DETERIORATED AND ROCKY SITES

Some spruce-fir sites (fig. 21) are badly deteriorated, with much of the original humus burned and washed away. Red spruce or Fraser

[5] Refer to Appendix, p. 80, for specifications for grading nursery stock on this basis.

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FIGURE 20.—Successful spruce plantations can be established under dense shrubby cover if the trees are released two or three times during the first 5 years.

fir can be planted with little difficulty in the soil pockets on these sites. Whether such thin soils will support vigorous tree growth in later years, however, is not known.

F-403759

FIGURE 21.—Cut-over and burned spruce–fir land. The organic matter in the soil has been completely burned away.

DIRECT SEEDING

Direct seeding should be considered a supplement to, but not a substitute for, planting. Except at high elevations where the ground remains frozen throughout the winter, alternate freezing and thawing heaves young seedlings. Uncertainties of weather, such as drought, make direct seeding less dependable than planting. Consequently, direct seeding should be used only on sites well adapted for its success and in circumstances where planting stock is unavailable or costs are so high that some degree of risk is justifiable. On exposed areas of soil or where vegetation is sparse, direct seeding practices should be as follows:

1. Prepare seed spots by removing vegetation on an area 2 to 3 feet in diameter.

2. Loosen the soil to a depth of 3 or 4 inches.

3. Sow 20 viable seeds in a 10-inch area at the center of the seed spot and rake in. Early spring sowing is recommended.

4. Place one-quarter to one-half inch of mulch over the sown spot.

Wire screens to keep out rodents, if placed over the sown spot and left for 3 years, will give slightly better survival and establishment of seedlings. The extra cost, however, probably is not justified by the slightly increased chances for success.

Improving Composition and Quality

Young spruce–fir stands are almost all confined to areas logged in the past 30 years. Such areas bear a high proportion of hardwood species. Because of the slow initial growth of spruce, the hardwoods, many of sprout origin, quickly gain dominance. Most of the hardwoods at the higher elevations are of inferior quality because of glaze damage. Pin cherry comes in prolifically on cut-overs but has no commercial value. Yellow birch, red maple, beech, and other species that are normally fair to good timber trees at lower elevations, are usually defective and of poor form when grown above 5,000 feet.

As in the case of planted spruce, natural spruce regeneration requires early release if it is to maintain vigorous growth. A tolerant species, red spruce will live under an overstory for many years. It exhibits marked growth energy and will respond quickly and vigorously to release. However, Buell (*6*) showed that after 5 years 48 percent of the young spruce trees released by CCC crews were overtopped or threatened. Thus, release may have to be repeated if aggressive hardwoods are present in the stand.

Hardwoods retained in cleaning operations as potential crop trees should be of desirable species with good form, free from defect, and preferably of seedling origin, or single sprouts rather than multiple sprout groups. The silvical characteristics of each species should guide selection of individual trees in cleanings.

In descending order of desirability, species that should be favored in cleanings are red spruce, yellow birch, Fraser fir, eastern hemlock, sweet birch, sugar maple, beech, and northern red oak. The latter four species will do best in the lower fringes of the type and can be favored more heavily than at higher elevations.

On the basis of growth energy or ability to respond to release, the species rate in decreasing order as follows: Red spruce, beech, sugar maple, hemlock, red maple, Fraser fir, northern red oak, yellow birch, and sweet birch.

The following rules govern cleaning in the young spruce–fir forest:

1. Make release cuttings on a crop-tree basis, selecting about 250 potential crop trees of desirable species, good form, and no defect. Cut only the growth that competes with selected crop trees.

2. Degree of release is dependent upon crop-tree height with respect to adjacent trees, condition of released tree, and its growth energy. For releasing tolerant or moderately tolerant species, cut (a) all trees taller than the crop tree that are within 4 feet of the outer edge of its crown, or (b) all trees reaching one-third of the way up the crown of the crop tree that are within 2 feet of the outer edge of its crown. Do not cut shorter trees. To release intolerant species, increase the distance of release to 6 feet and 3 feet, respectively. Unless red spruce is 10 to 15 feet tall at time of release, a second cleaning will probably be necessary in 10 years.

3. If hardwoods are needed to fill out the spacing between spruce crop trees, select for release the straight, sound individuals of seedling or seedling sprout origin. Cut high-origin sprouts, sprouts from large

stumps, or crooked, rough hardwoods if overtopping smaller, more desirable hardwoods.

Release from Overhead Competition

Even where spruce–fir forests have been clear-cut, there often remains a partial stand of large unmerchantable hardwoods. Most of these are not only highly defective and of poor form, but they interfere with young conifers and desirable hardwood reproduction by overtopping the small trees. Under such conditions, liberation of the young growth is desirable by girdling or otherwise disposing of the overstory. However, as emphasized previously, there is no point in removing large trees, even though defective, unless valuable reproduction is thereby released.

Korstian (*28*) shows how effective the liberation of spruce can be. He reports a case in West Virginia where striking increases in the diameter growth of spruces had followed release 35 years before, as shown below:

Average diameter at time of release (inches):	*Average diameter 35 years after release (inches)*	*Expected diameter after 35 years at original growth rate (inches)*
1.2	9.1	3.1
4.1	11.0	5.4
8.2	14.1	10.3
10.9	15.6	13.1

Westveld (*53*) found that growth of spruce and fir on an area where the overwood had been girdled was five times faster than the growth on an adjacent untreated area.

Liberation is accomplished by girdling, poisoning, or felling the overtopping trees. Girdling or poisoning is generally preferred to felling, because of lower cost. These preferred methods also result in less damage to advance reproduction than does felling, since dead standing trees decay and tend to fall slowly limb by limb.

Girdling of hold-over defective northern hardwoods should ordinarily be postponed for several years until evidence is available to indicate what benefits to reproduction can be obtained by the treatment. Another reason for delay is that many of the hold-over hardwoods associated with spruce commonly die following logging.

When defective hardwoods are girdled, special care should be taken to see that bark folds at the margins of basal catfaces are completely severed. Diffuse-porous species like beech, birch, and maple resist the effects of girdling and even a very narrow bark bridge may keep the tree alive.

Poisoning is an effective way to dispose of unwanted trees. Specifications for mixing poison solutions and applying them are discussed in the Appendix. The newer silvicides, such as 2,4-D and Ammate, have many advantages over other poisons, although their effectiveness has not yet been thoroughly tested on all species. The best available information on the use of silvicides is given on pages 18 and 19.

Thinning Spruce Stands

On cut-over areas where fire has been kept out, spruce often seeds in thickly, some patches having as many as 4,000 trees per acre at 25 years of age. These dense thickets tend to stagnate unless thinned moderately at about the twenty-fifth year. Early thinnings at this age are expensive, since they yield no commercial product, but if made later the stands are subject to windthrow on the thin rocky soils where spruce grows.

Thinning should be done on a crop-tree basis, reserving the best formed and most vigorous trees for growth. In pure spruce–fir thickets, spruce should be favored with about a 7-foot spacing at 25 years of age when the tree will average 3 inches in d.b.h. Suppressed spruce and noncompeting hardwoods should not be cut. Where spruce is not present in sufficient numbers, Fraser fir, hemlock, or the better hardwoods should be favored as crop trees.

Later thinnings cannot unqualifiedly be recommended. In many of the inaccessible mountain areas, economic conditions will determine the desirability of thinnings. Unless early thinnings are made, late thinnings are not recommended. The value of late thinnings lies primarily in increasing quality increment. Total volume is not increased materially by late thinning in which the smaller, less vigorous trees are removed.

If quality production is the goal of management, spruce stands should be thinned to 550 trees per acre (9-foot spacing) at age 65, and to 300 trees per acre (12-foot spacing) at age 100 (*38*).

Sustained management on 50-year rotations will produce the greatest volume of wood without regard to quality. This objective would require thinning to the following densities:

Average d.b.h. (inches):	*Spacing (feet)*	*Trees (number)*
5	6 × 7	1,000
7	7 × 8	800
8	8 × 9	600

The accompanying data are approximated from stand and yield tables given by Murphy (*38*).

Improvement of Saw-Timber Stands

Little can be done to improve a saw-timber stand of spruce and fir. As previously pointed out, stand improvement should start with the young forest. Saw-timber stands that contain hardwood culls, wolf trees, or other undesirables can be improved by girdling or poisoning these undesirable trees. Desirable reproduction can often be obtained in openings created in this manner.

Spruce–fir stands can be harvested by the tree- or group-selection method and successfully regenerated. Where this system is employed, the first cut should remove the decadent, defective, and injured trees.

Pruning

Pruning of spruce and fir is not recommended. At the high elevations where the type occurs, growth rates are slow, and large-sized

high-quality trees probably can never be grown at a profit. Because of the slow growth rate, few of the trees selected for pruning will accumulate sufficient volumes of knot-free lumber in a reasonable time to make the investment in pruning a profitable one.

PLANTATION CARE[6]

The acreage of plantations established in the Appalachian region is not known, but it has been estimated that there are about 3 million plantable acres not now bearing trees and not likely to restock naturally in a reasonable time. Consequently, plantation care will become increasingly important as these lands are restocked. Unlike most natural stands, plantations always require a capital outlay during establishment. Thus, although they may be no better or not even as good as natural stands, their proper culture is especially important to protect this original investment by promoting the maximum growth and quality of timber.

Because of their uniform composition, age, and tree size, plantations are more susceptible to injury by diseases and insects than the less-uniform natural stands. Thinning to improve quality and maintain good diameter growth rates, and pruning to produce clear butt logs are the principal cultural measures necessary in plantations. The proper application of these treatments can reduce losses from pests.

Damage from Disease and Insects

YELLOW PINES

The most commonly planted of the yellow pines in the Appalachian region are shortleaf and loblolly. Both are susceptible to a number of diseases and insects, but ordinarily can be counted upon to provide adequately stocked stands of good trees when planted 6 by 8 feet or closer.

Plantings of loblolly pine made in areas where the pointed-leaved oaks are abundant are likely to suffer losses from the fusiform rust (fig. 12, *B*). Most trunk-cankered trees will die, break over, or produce little timber of value (*47*). Stands planted as close as 6 by 6 feet can, however, lose as many as 30 percent of the trees from canker and still retain adequate stocking. The elimination of these trees represents a money loss only when the mortality is in groups, leaving large gaps, or when the dead trees might have produced salable thinnings. Where there are branch cankers within 6 inches of the trunk, the trunk is likely to be already infected. The development of some stem cankers can be prevented by repeated pruning during the first 5 years, eliminating branch cankers that might otherwise spread to the stem.

The removal of stem-cankered trees has little sanitary effect in a plantation, but they should be cut when thinnings are made so that they can be salvaged and provide more space for the better trees. Shortleaf pine rarely takes the fusiform rust, but is sometimes attacked

[6] It is not within the scope of this publication to discuss plantation establishment. For a good summary of this subject see the bulletin by Minckler and Chapman (*36*).

by the very similar round gall rust (*Cronartium cerebrum*) which usually does only minor damage. The round form also occurs abundantly on Virginia pine and to some extent on loblolly.

In young loblolly pine stands exposed to the possibility of heavy cankering, or already heavily cankered, as high a density as possible, consistent with reasonable growth, should be maintained. In dense stands the percentage of stem-cankered trees is comparatively low because the early death of shaded limbs prevents many branch cankers from reaching the trunk (*30, 37*).

Young planted yellow pines in certain years develop epidemics of leaf fungus attacks. The needle rusts may become so abundant in the spring that one's clothes become orange-colored with their spores, and yet these fungi have no noteworthy effect on growth. Needle casts may cause a heavy browning and shriveling of the older foliage, but again no lasting or important amount of damage generally results from these attacks. Repeated attacks, however, will weaken trees.

Occasional leaders and branches are lost due to Atropellis canker and pitch canker, the former attacking mainly shortleaf and loblolly, the latter preferring Virginia pine. The pitch canker appears to be a new disease and its full potentialities are not yet understood.

Some yellow pine plantations are heavily attacked year after year by tip moths, with the result that most of the trees become multiple-stemmed, bushy, and worthless. During certain years plantations are defoliated by sawfly larvae. A complete defoliation weakens pines seriously and may kill them. Two successive defoliations will invariably kill. Matsucoccus scale insects can cause extensive twig blighting. Twig death also is commonly associated with the chewing of the bark by weevils, sawyer beetles, and other insects.

Rapid strides are now being made in the field of new insecticides, with an ever-changing picture of relative merits of different materials. The latest information on control measures for the yellow pine plantation insects can be obtained from the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington 25, D. C.

WHITE PINE

In order to avoid blister rust (fig. 12, *A*, and page 67 in the Appendix) where white pine is planted, precautions should be taken to insure that no currants or gooseberry bushes occur within 900 feet of the plantation. These species of Ribes should be eradicated if they are found, and the European black currant should not be tolerated within a quarter mile of a white pine plantation.

The white pine weevil can be very damaging to white pine plantations by killing leaders, thus producing brushy worthless trees. The more dominant trees are likely to be the more heavily damaged. Many severely weeviled plantations can be reclaimed by removing these malformed, dominant trees in favor of unweeviled straight trees in the lower canopy, especially in the intermediate crown class.

Mixed plantations are usually weeviled much less severely than pure white pine. On good sites, with several inches of topsoil, yellow-poplar

grows well in mixture with white pine, is easy to establish, and is a desirable species for pulpwood and sawlogs. A good pattern for this mixture involves a checkerboard arrangement with square blocks of 9 trees per block of a single species. A spacing of 6 by 6 feet is satisfactory.

The pine bark aphid produces a conspicuous cottony coating on trunks and branches but does little or no damage. There are also other aphids and scale insects affecting white pine, but they rarely produce more than minor effects on growth or form.

SPRUCE AND FIR

Planted spruce and fir are usually free from destructive pests in the southern Appalachians. The budworm is not a factor in this region, and the spruce gall aphid, needle rusts, and other needle diseases are generally of minor importance.

Thinning and Pruning

Plantations, with trees usually spaced 6 by 8 feet apart, will close naturally and become densely stocked at about 10 years of age. In stands where trees are less than pulpwood size, thinnings are not necessary as a rule, because the pine species commonly planted express dominance with sufficient vigor to avoid stagnation. Early commercial thinings are desirable, however, to remove poorly formed, rough, and diseased trees, and to provide crown space for subsequent growth.

The rules set forth for pine thinning on pages 35 to 38 should be followed in thinning plantations. Maintenance of live crowns equal in length to one-third of total tree height is important. Thinnings should be made when crown length is reduced to less than this fraction.

Plantations with wide spacings, like natural old-field stands, tend to produce rough limby trees. For high quality production, pruning is often desirable. The recommendations previously given on pages 42 to 45 apply also to plantations. Not more than about 100 of the best trees on each acre should be pruned, and particular attention must be paid to the selection of disease-free, undamaged individuals. Fusiform rust damage, common in loblolly pine plantations, can be held to a minimum by pruning off branch cankers, providing the canker is more than 6 inches from the bole at time of pruning.

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APPENDIX

Forest Cover Types Included in Major Type Classes

There follows a list, under each major type class, of the forest cover types recognized by the Society of American Foresters (S.A.F.) (*49*).

HARDWOOD TYPE

S.A.F. type No.	*Cover type*
12.	Sugar maple – beech – yellow birch.
14.	Sugar maple.
14–a.	Black cherry.
30.	Post oak.
31.	Post oak – blackjack oak.
32.	Black oak – post oak.
33.	Scarlet oak – black oak.
34.	Southern red oak – scarlet oak.
35.	Bear oak.
36.	Chestnut oak.
47.	Black locust.
49.	White oak – black oak – red oak.
50.	White oak.
51.	Red oak – basswood – white ash.
52.	Red oak.
53.	Yellow-poplar.
54.	Yellow-poplar – hemlock.
55.	Yellow-poplar – white oak – red oak.
57.	Beech – sugar maple.
58.	Beech.
59.	River birch – sycamore.
77.	Red gum [sweetgum] – yellow-poplar.

PINE–HARDWOOD TYPE

S.A.F. type No.	*Cover type*
39.	Shortleaf pine – post oak.
40.	Shortleaf pine –southern red oak – scarlet oak.
41.	Shortleaf pine – white oak.
43.	Virginia pine – southern red oak.
46.	Eastern redcedar.
48.	White pine – chestnut oak – chestnut.
71.	Loblolly pine – white oak.

PINE TYPE

S.A.F. type No.	*Cover type*
9.	White pine.
10.	White pine – hemlock.
11.	Hemlock.
37.	Pitch pine.
38.	Shortleaf pine.
42.	Shortleaf pine – Virginia pine.
44.	Virginia pine.
68.	Loblolly pine – shortleaf pine.
69.	Loblolly pine.

SPRUCE–FIR TYPE

S.A.F. type No.	*Cover type*
5.	Pin cherry.
15.	Yellow birch (cut-overs).
16.	Yellow birch – red spruce.
18.	Red spruce.
19.	Red spruce – southern balsam fir.

TABLE 5—*Tree species of commercial importance in the southern Appalachian region, and their requirements and major uses*

Species	General desirability for timber production	Degree of tolerance	Site for best development	Optimum elevation range (feet)	Cover types in which species reaches best development[1]	Major uses and special characteristics of wood
Ash, Biltmore	High	Intermediate	Moist	2,500–4,000	10, 12, 51, 54	Handles, cooperage, furniture, athletic goods.
Ash, green	Moderate	do	Intermediate	500–1,000	49	Do.
Ash, red	do	do	Moist	500–1,000	71, 77	Do.
Ash, white	High	do	do	2,500–4,000	10, 12, 51, 54	Do.
Basswood	do	High	do	2,500–4,000	10, 12, 51, 54	Boxes, woodenware, venetian blinds, luggage, veneer.
Beech, American	Low	do	do	3,500–5,000	12, 15, 16, 57, 58	Boxes, baskets, distillation, veneer, cooperage.
Birch, sweet	Moderate	Low	Intermediate	2,000–4,500	9, 10, 12, 51, 53	Lumber, veneer, distillation, furniture, ties, fuel, textile bobbins, novelties.
Birch, yellow	do	do	Moist	3,500–6000	11, 12, 15, 16, 19	Lumber, veneer, distillation, furniture, ties, fuel, textile bobbins, novelties.
Blackgum	Low	High	Intermediate	500–4,000	32, 33, 34, 40, 44, 49, 68	Veneer, lumber, boxes, crates, furniture.[2] Has cross grain.
Buckeye, yellow	do	do	Moist	3,000–5,000	14a, 15, 16, 18, 51	Boxes, crates, caskets, luggage, woodenware.
Butternut	do	Low	do	2,000–4,000	14a, 49, 51	Furniture, boxes, crates.[2]
Cherry, black	High	do	do	1,000–5,000	12, 14a, 51, 57	Furniture, electrotype plate blocks, trim.[2]
Chestnut, American	Low					Posts, poles, caskets, tannin extract, trim, furniture.
Cucumbertree	High	Intermediate	do	3,000–5,000	12, 53, 54	Lumber, furniture, boxes, crates, venetian blinds.
Dogwood, flowering	do	High	Intermediate to moist.	1,000–4,000	32, 33, 49, 55	Textile shuttles, bobbins.[2] Hard, close-textured wood.
Elm, American	Moderate	Intermediate	Moist	3,000–5,000	12, 49, 51, 57, 58	Boxes, baskets, slack cooperage, caskets. Good bending properties.
Fir, Fraser	do	High	do	4,000–6,500	16, 18, 19	Pulpwood, boxes, crates.
Hemlock, eastern	do	do	do	2,000–5,000	9, 10, 11, 15, 19, 54	Lumber, pulpwood, tannin from bark.
Hickory, bitternut	Low	Intermediate	Intermediate	1,000–4,000	33, 34, 39, 49, 58	Handles, sporting goods, picker sticks, furniture.[2]

Hickory, mockernut	do	do	do	1,000–4,000	31, 34, 50, 57, 58	Do.[2]
Hickory, pignut	do	High	do	1,000–3,500	33, 49, 57, 58	Do.[2]
Hickory, red	do	Intermediate	do	500–1,500	33, 34, 39, 40	Do.[2]
Hickory, shagbark	do	do	Moist	1,000–4,500	49, 50, 55, 57, 58	Do.[2]
Hickory, shellbark	do	High	do	500–2,500	33, 34, 39, 40, 57, 58	Do.[2]
Honeylocust	do	Low	Dry	500–1,500	31, 39, 44	Fuel, fence posts, furniture, trim, wheel hubs.[2]
Locust, black	Moderate	do	Dry to moist.	1,500–3,000	33, 46, 47, 49, 53	Posts, mine timbers, insulator pins. Very durable.
Maple, red	do	High	Intermediate to moist.	500–4,000	11, 12, 15, 16, 31, 32, 44, 49, 53, 59	Furniture, distillation, veneer, pulp, woodenware, flooring.
Maple, sugar	High	do	Moist	3,000–5,000	12, 14, 16, 18, 51, 54, 57	Furniture, distillation, veneer, pulp, woodenware, flooring, bowling pins.
Oak, black	Moderate	Low	Intermediate	500–3,500	32, 33, 34, 36, 49, 55	Lumber, ties, mine timbers, fuel, flooring, cooperage, furniture.[2]
Oak, chestnut	do	do	Dry to intermediate.	1,000–3,500	30, 33, 36, 37, 48, 52	Lumber, ties, mine timbers, fuel, flooring, cooperage, furniture, tannin from bark.[2]
Oak, chinquapin	do	Intermediate	do	500–1,500	30, 31	Lumber, ties, mine timbers, fuel, flooring, cooperage, furniture.
Oak, northern red	High	do	Intermediate to moist.	2,000–4,500	41, 49, 51, 52, 53, 55	Do.[2]
Oak, post	Low	do	Dry to intermediate.	500–2,500	30, 31, 32, 36, 39, 40, 41, 42, 43	Do.
Oak, scarlet	Moderate	Low	do	1,500–3,500	30, 31, 32, 33, 34, 38, 40, 42, 52	Do.
Oak, southern red	do	do	do	500–2,000	32, 34, 40, 41, 42, 43	Do.
Oak, water	Low	do	Intermediate to moist.	500–1,000	69, 71	Do.
Oak, white	High	Intermediate	do	500–4,500	30, 32, 33, 36, 41, 49, 50, 55	Lumber, ties, mine timbers, fuel, flooring, cooperage, furniture, whiskey barrels, veneer.[2] Preferred to other oaks.
Oak, willow	Low	Low	do	500–1,000	69, 71	Lumber, ties, mine timbers, fuel, flooring, cooperage, furniture.

[1] Numbers refer to types recognized by the Society of American Foresters, See p. 59.
[2] High game food value.
[3] Not native; commercially important where planted.

TABLE 5—*Tree species of commercial importance in the southern Appalachian region, and their requirements and major uses* (continued)

Species	General desirability for timber production	Degree of tolerance	Site for best development	Optimum elevation range (feet)	Cover types in which species reaches best development[1]	Major uses and special characteristics of wood
Persimmon, common	Low	Low	Dry	500–1,500	68	Golf club heads, shuttles.[2]
Pine, eastern white	High	Intermediate	Intermediate to moist.	1,500–3,500	9, 10, 11, 36, 48	General lumber, boxes, pulp, millwork, excelsior. Fine-grained wood, easily worked.
Pine, loblolly	do	do	Dry to intermediate.	500–1,500	68, 69, 71, 77	Construction lumber, timbers, pulp, veneer, boxes, crates.
Pine, pitch	Moderate	Low	Dry	1,000–3,500	33, 35, 36, 37, 38, 42, 43	Do.
Pine, red[3]		do	Dry to intermediate.			
Pine, shortleaf	High	do	do	500–2,500	30, 38, 39, 40, 41, 42, 43, 44, 68	Construction lumber, timbers, pulp, veneer, boxes, crates.
Pine, Virginia	Moderate	do	Dry	500–2,500	34, 38, 42, 43, 44	Do.
Redcedar, eastern	High	Intermediate	do	500–2,000	31, 46	Fence posts, chests, closets, boats, pencils. Durable wood.
Spruce, red	do	High	Moist	4,000–6,500	10, 11, 14a, 16, 18, 19	Pulp, lumber, boxes, crates.
Sweetgum	do	Intermediate	Intermediate to moist.	500–1,500	44, 68, 69, 77	Lumber, veneer, furniture, boxes, crates.
Sycamore, American	Low	Low	Moist	500–2,500	59	Lumber, ties, veneer, cooperage, fuel.
Walnut, black	High	do	Intermediate	1,000–3,000	49, 55	Furniture, cabinets, gunstocks, veneer.
White-cedar, northern.	Moderate	High	Moist	4,000–6,000	18	Poles, ties, lumber, posts.
Willow, black	Low	Low	do	1,000–2,500	59	Lumber, artificial limbs, cooperage, pulp, veneer, excelsior.
Yellow-poplar	High	do	do	500–4,000	9, 10, 50, 52, 53, 54, 55, 69, 77	Lumber, veneer, pulp, furniture, excelsior. Fine-grained, easily worked wood.

[1] Numbers refer to types recognized by the Society of American Foresters, See p. 59.
[2] High game food value.
[3] Not native; commercially important where planted.

Common and Scientific Names of Trees,[1] Shrubs, and Vines[2] in the Southern Appalachian Region

COMMERCIALLY IMPORTANT TREE SPECIES

Common name	*Scientific name*
Ash, Biltmore	*Fraxinus biltmoreana* Beadle
Ash, green	*F. pennsylvanica* var. *lanceolata* (Borkh.) Sarg.
Ash, red	*F. pennsylvanica* Marsh.
Ash, white	*F. americana* L.
Basswood	*Tilia* L.
Beech, American	*Fagus grandifolia* Ehrh.
Birch, sweet	*Betula lenta* L.
Birch, yellow	*B. lutea* Michx. f.
Blackgum	*Nyssa sylvatica* Marsh.
Buckeye, yellow	*Aesculus octandra* Marsh.
Butternut	*Juglans cinerea* L.
Cherry, black	*Prunus serotina* Ehrh.
Chestnut, American	*Castanea dentata* (Marsh.) Borkh.
Cucumbertree	*Magnolia acuminata* L.
Dogwood, flowering	*Cornus florida* L.
Elm, American	*Ulmus americana* L.
Fir, Fraser	*Abies fraseri* (Pursh) Poir.
Hemlock, eastern	*Tsuga canadensis* (L.) Carr.
Hickory, bitternut	*Carya cordiformis* (Wangenh.) K. Koch
Hickory, mockernut	*C. tomentosa* Nutt.
Hickory, pignut	*C. glabra* (Mill.) Sweet
Hickory, red	*C. ovalis* (Wangenh.) Sarg.
Hickory, shagbark	*C. ovata* (Mill.) K. Koch
Hickory, shellbark	*C. laciniosa* (Michx. f.) Loud.
Honeylocust	*Gleditsia triacanthos* L.
Locust, black	*Robinia pseudoacacia* L.
Maple, red	*Acer rubrum* L.
Maple, sugar	*A. saccharum* Marsh.
Oak, black	*Quercus velutina* Lam.
Oak, chestnut	*Q. montana* Willd.
Oak, chinquapin	*Q. muehlenbergii* Engelm.
Oak, northern red	*Q. borealis* Michx. f.
Oak, post	*Q. stellata* Wangenh.
Oak, scarlet	*Q. coccinea* Muenchh.
Oak, southern red	*Q. falcata* Michx.
Oak, water	*Q. nigra* L.
Oak, white	*Q. alba* L.
Oak, willow	*Q. phellos* L.
Persimmon, common	*Diospyros virginiana* L.
Pine, eastern white	*Pinus strobus* L.
Pine, loblolly	*P. taeda* L.
Pine, pitch	*P. rigida* Mill.
Pine, red[3]	*P. resinosa* Ait.
Pine, shortleaf	*P. echinata* Mill.
Pine, Virginia	*P. virginiana* Mill.
Redcedar, eastern	*Juniperus virginiana* L.
Spruce, red	*Picea rubens* Sarg.
Sweetgum	*Liquidambar styraciflua* L.
Sycamore, American	*Platanus occidentalis* L.

[1] Common and scientific names of trees species according to "Check List of the Native and Naturalized Trees of the United States, Including Alaska" (*51*).

[2] Common and scientific names of shrubs and vines according to "Standardized Plant Names" (*1*).

[3] Not native; commercially important where planted.

Common name	*Scientific name*
Walnut, black	*Juglans nigra* L.
White-cedar, northern	*Thuja occidentalis* L.
Willow, black	*Salix nigra* Marsh.
Yellow-poplar	*Liriodendron tulipifera* L.

TREE SPECIES UNIMPORTANT COMMERCIALLY

Common name	*Scientific name*
Apple[4]	*Malus* Mill.
Aspen, bigtooth	*Populus grandidentata* Michx.
Aspen, quaking	*P. tremuloides* Michx.
Birch, river	*Betula nigra* L.
Boxelder	*Acer negundo* L.
Buckeye, Ohio	*Aesculus glabra* Willd.
Cherry, pin[4]	*Prunus pensylvanica* L. f.
Chokecherry, common[4]	*P. virginiana* L.
Coffeetree, Kentucky	*Gymnocladus dioicus* (L.) K. Koch
Cottonwood, eastern	*Populus deltoides* Bartr.
Elm, slippery	*Ulmus fulva* Michx.
Elm, winged	*U. alata* Michx.
Hackberry	*Celtis occidentalis* L.
Hawthorn[4]	*Crataegus* L.
Hemlock, Carolina	*Tsuga caroliniana* Engelm.
Hickory, Carolina	*Carya carolinae-septentrionalis* (Ashe) Engl. and Graebn.
Holly, American[4]	*Ilex opaca* Ait.
Hophornbeam, eastern[4]	*Ostrya virginiana* (Mill.) K. Koch
Hornbeam, American[4]	*Carpinus caroliniana* Walt.
Magnolia, bigleaf	*Magnolia macrophylla* Michx.
Magnolia, Fraser[4]	*M. fraseri* Walt.
Magnolia, umbrella[4]	*M. tripetala* L.
Maple, black	*Acer nigrum* Michx. f.
Maple, silver	*A. saccharinum* L.
Maple, striped[4]	*A. pensylvanicum* L.
Mountain-ash, American[4]	*Sorbus americana* Marsh.
Mulberry, red[4]	*Morus rubra* L.
Oak, bear[4]	*Quercus ilicifolia* Wangenh.
Oak, blackjack[4]	*Q. marilandica* Muenchh.
Oak, shingle	*Q. imbricaria* Michx.
Pine, Table-Mountain	*Pinus pungens* Lamb.
Plum, American[4]	*Prunus americana* Marsh.
Poplar, balm-of-Gilead	*Populus tacamahaca* var. *candicans* (Ait.) Stout
Redbud, eastern[4]	*Cercis canadensis* L.
Sassafras[4]	*Sassafras albidum* (Nutt.) Nees
Serviceberry, downy[4]	*Amelanchier arborea* (Michx. f.) Fern.
Silverbell, Carolina[4]	*Halesia carolina* Ellis
Silverbell, mountain[4]	*H. monticola* (Rehd.) Sarg.
Sourwood[4]	*Oxydendrum arboreum* (L.) DC.
Sugarberry[4]	*Celtis laevigata* Willd.
Sweetbay[4]	*Magnolia virginiana* L.
Yellowwood[4]	*Cladrastis lutea* (Michx. f.) K. Koch

SHRUBS AND VINES COMMON IN THE REGION

Common name[5]	*Scientific name*
Alder[5]	*Alnus* Mill.
Amorpha	*Amorpha*

[4] Trees commonly do not develop to sawlog size.

[5] Species generally or locally abundant that sometimes interfere with reproduction of desirable tree species. The list includes some species that occasionally reach small tree size.

Common name	*Scientific name*
Azalea	*Azalea*
Bittersweet, American	*Celastrus scandens*
Blackberry[5]	*Rubus*
Bladdernut, American	*Staphylea trifolia* L.
Blueberry[5]	*Vaccinium* L.
Buckthorn, Carolina	*Rhamnus caroliniana* Walt.
Bushhoneysuckle	*Diervilla*
Buttonbush, common	*Cephalanthus occidentalis* L.
Ceanothus, Jerseytea[5]	*Ceanothus americanus*
Chokeberry, black	*Aronia melanocarpa*
Chinquapin, Alleghany[5]	*Castanea pumila* (L.) Mill.
Clethra	*Clethra*
Currant	*Ribes*
Devils-walkingstick	*Aralia spinosa* L.
Dogwood (shrubby species)	*Cornus* L.
Dutchmanspipe, common	*Aristolochia durior*
Elder[5]	*Sambucus* L.
Euonymus, brook	*Euonymus americanus*
Fern, eastern bracken	*Pteridium latiusculum*
Filbert (Hazelnut)[5]	*Corylus*
Fringetree, white	*Chionanthus virginicus* L.
Gooseberry	*Ribes*
Grape[5]	*Vitis*
Greenbrier[5]	*Smilax*
He-huckleberry	*Lyonia ligustrina*
Holly (shrubby species)	*Ilex* L.
Honeysuckle	*Lonicera*
Hoptree, common	*Ptelea trifoliata* L.
Huckleberry[5]	*Gaylussacia*
Hydrangea, smooth[5]	*Hydrangea arborescens*
Kalmia, mountainlaurel	*Kalmia latifolia* L.
Leucothoe, drooping	*Leucothoe catesbaei*
Locust (shrubby species)	*Robinia* L.
Menziesia, Allegany	*Menziesia pilosa*
Mockorange	*Philadelphus*
Mountain maple[5]	*Acer spicatum* Lam.
Oilnut, Allegany	*Pyrularia pubera*
Papaw, common	*Asimina triloba* (L.) Dunal.
Pieris, mountain	*Pieris floribunda*
Raspberry[5]	*Rubus*
Rhododendron[5]	*Rhododendron* L.
Rose[5]	*Rosa*
Spicebush, common[5]	*Lindera benzoin*
Spirea	*Spiraea*
Sumac[5]	*Rhus* L.
Sweetfern, littleleaf[5]	*Comptonia peregrina asplenifolia*
Sweetleaf, common	*Symplocos tinctoria*
Sweetshrub, common	*Calycanthus floridus*
Viburnum[5]	*Viburnum* L.
Virginia creeper[5]	*Parthenocissus quinquefolia*
Witchhazel, common	*Hamamelis virginiana* L.
Yellowroot	*Xanthorhiza simplicissima*

[5] Species generally or locally abundant that sometimes interfere with reproduction of desirable tree species. The list includes some species that occasionally reach small tree size.

Mixing and Application of Sodium Arsenite Poisoning Solution

MIXING SODIUM ARSENITE SOLUTION

Sodium arsenite poisoning solution can be prepared by making a paste of 8 pounds of sodium arsenite powder and 1 quart of lukewarm water. Add 3 more quarts of water and stir thoroughly. To this suspension add carefully 2 pounds of lye. The resulting stock solution should be diluted with 4 volumes of water to 1 of stock solution before application to trees or stumps.

CAUTION: Both sodium arsenite and lye are deadly poisons. The fumes of the solution are also very poisonous. Always prepare poisonous solutions out of doors. Even when mixing out of doors it is safer to wear a full facepiece respirator fitted with a filter element designed to eliminate the fumes of this solution. It is also safer to wear rubber gloves and leave no part of the body exposed to spattering of the chemicals. Store stock solution in locked compartments. Thoroughly clean all vessels used in mixing and applying before putting them away. Thoroughly clean all spattered clothing before wearing or putting away.

APPLICATION OF SODIUM ARSENITE SOLUTION TO TREES

Solutions should be applied in bore holes or hacked frills near the base of the tree. Holes should be ½ inch in diameter and 1 to 2 inches deep. A 3-inch tree requires one hole. For each 2 inches of additional diameter, one more hole is needed, so that a 5-inch tree should have two holes, a 7-inch tree three holes, etc.

Holes may be bored with tree augers or punched with special tools. A punch-ax combination (*40*) is commercially manufactured. With one blow of this tool, a hole ½ inch in diameter, 1 to 2 inches deep, is made. The poison solution is poured in the holes from a long-spouted container such as a locomotive engineer's oil can, old coffee pot, or battery water jar. About 1 or 2 tablespoonsful of liquid should be applied to each hole.

Poison can be applied in ax cuts or frills made near the tree base with downward strokes of an ax or other tool. Chips are allowed to remain in the cut, to better hold the poison solution. A continuous frill around the tree is desirable, and in no case should unsevered strips of bark more than 1 inch wide be left. A small amount of poison liquid is poured into the frill around the tree's circumference.

CAUTION: Animals, particularly livestock and deer, are sometimes attracted to poisoned trees and stumps and may lick up sufficient poison to kill themselves. Livestock should be excluded for 3 days from areas after poison is used. Avoid spilling solutions on the ground. Workers should wash hands thoroughly immediately after using poison, and before touching food. All equipment should be cleaned thoroughly and stored where it cannot be reached by children.

The More Common or Important Appalachian Tree Diseases

WHITE PINE BLISTER RUST

White pine blister rust, caused by *Cronartium ribicola*, is characterized on pine by stem or branch cankers. Between April and June, blisters containing the orange spores of the aecial stage appear on the cankers (fig. 12, *A*). These spores infect currant and gooseberry leaves where the fungus develops in two stages. First, during the summer, it produces orange pustules (uredia) containing spores that infect other Ribes plants; later in the summer, and in the fall, it produces small hairlike columns (telia) on which are developed the spores that infect the pines.

In about 10 percent of the white pine growing area of the southern Appalachians, especially in Virginia and West Virginia, species of Ribes are associated with the white pine. The Ribes occur largely at elevations above 3,000 feet. The hazard of the white pine blister rust is high on such areas. The rust now occurs as far south as North Carolina and is spreading slowly southward. The Ribes should be eradicated from white pine areas, and for a distance of 900 feet around them, if losses from blister rust are to be avoided. Periodic rechecking and re-eradication are necessary following the initial eradication.

LITTLELEAF DISEASE OF PINE

Littleleaf affects primarily shortleaf pine and, to a lesser degree, loblolly pine. In the Appalachian region it occurs only in the Piedmont. It is characterized by short chlorotic needles, greatly reduced twig growth, and premature death. Only trees approaching or over 20 years old are affected (*24*). The cause is not known. Diseased trees invariably die early, the average time from the first appearance of symptoms to death being 7 years. Losses from littleleaf can be minimized by salvaging affected trees before they die, and by favoring other species in improvement cuts. No control measures are yet known.

FUSIFORM RUST OF SOUTHERN PINES

The fusiform rust, caused by *Cronartium fusiforme*, which produces spindle-shaped swellings on the trunks and branches, causes major losses to slash and loblolly pine in some sections (*47*). A similar but much less destructive fungus, *C. cerebrum*, produces round galls on Virginia, shortleaf, and loblolly pines. Blisters containing the orange spores of the aecial stage are produced on the cankers in early spring. Shortly thereafter, the disease develops on oak leaves, the uredial stage appearing as small orange pustules, and the telial stage as hairlike projections. Pine is reinfected by the telial stage on the oak. Stem-cankered pines either die, become badly deformed, or develop weakness to wind breakage.

Control of fusiform rust by the eradication of oaks is impractical. However, where attacks are heavy in young stands, particularly plantations, much mortality from stem cankers can be prevented by maintaining a high density to achieve early natural pruning, and by

pruning branch cankers before the rust invades the stem. For the first 5 years after planting, all branches bearing cankers less than 15 to 18 inches from the trunk should be removed from crop trees. Practices that tend to cause the pines to leaf out earlier in the spring, such as cultivating, fertilizing, and burning, tend to increase the incidence of fusiform rust (*47*).

ATROPELLIS CANKER OF PINE

Atropellis canker, caused by *Atropellis tingens*, occurs on the twigs and branches of pitch, loblolly, slash, and shortleaf pine. Small, black, irregularly cup-shaped fruiting bodies are generally associated with the cankers. Cankered twigs and branches generally die. Atropellis cankers can be distinguished from others by the fact that the wood under the cankers is always deeply stained black. This disease rarely does important damage.

PITCH CANKER

Pitch canker, caused by a form of *Fusarium lateritium*, is a recently discovered disease affecting chiefly Virginia and slash pine. It kills branches and small trunks, and is locally destructive in several States, but is not known to be distributed generally, at least yet. Its chief characteristic is excessive gum flow over the canker, and the wood beneath the canker is unstained but heavily infiltrated with gum. No fungus fruiting has been observed on natural cankers.

NEEDLE DISEASES

The southern pines are subject to three common needle diseases: rusts, needle cast, and brown spot. Needle rusts appear as yellowish blisters, bearing orange spores on the needles in the spring. Even when abundant, the needle rusts do little damage.

Needle cast is caused by several fungi, chiefly *Lophodermium pinastri* and *Hypoderma lethale*. They cause a striking browning and death of the needles during the winter and spring, and frequently cause loblolly and slash pines to lose all of their older needles. New needles usually emerge in a healthy condition in the spring and the trees suffer no damage unless such defoliations are recurrent.

Brown spot, caused by *Scirrhia acicola*, is chiefly a disease of young longleaf pine but occurs to some extent on all southern pines (*46*). In its killing effect on the foliage of loblolly pine, it is not easily distinguishable from the leaf casts, and the task of determining the needle blight fungi is one for the specialist. The needle diseases are controllable by spraying, but this method is not feasible under forest conditions. In longleaf pine brown spot is controllable by prescribed burning (*52*), but loblolly pine seedlings cannot survive the use of fire.

NECTRIA CANKER

Nectria canker affects a great many hardwoods, chiefly black walnut, the birches, yellow-poplar, red maple, basswood, and in the

Alleghenies, the oaks. The causal fungus on most species is *Nectria galligena*, and the cankers on yellow-poplar are caused by *N. magnoliae*. The disease is readily recognized by the characteristic "target" cankers resulting from the killing back of successive callus folds (fig. 3, *A*). The spores are produced in small red balloonlike structures over and around the edges of the cankers. Attempts to reduce subsequent cankering by repeated eradication of cankered trees on two large experimental areas in Maryland have not proved to reduce subsequent cankering as compared with adjacent uneradicated areas. In the South very little new trunk cankering takes place after a stand passes about 25 years of age, and therefore there is no need for attempting to influence canker development in pole stands. Cankered trees should be avoided as crop trees in improvement operations.

STRUMELLA CANKER OF OAK

Strumella canker, which affects primarily the oaks and occasionally other hardwoods from the North Carolina-Virginia line northwards, is caused by *Strumella coryneoidia*. The red and black oaks are more susceptible than the white oaks. On young smooth-barked trees the lesions are sunken, irregular, with concentric ridges, and with conspicuous lips. The bark usually adheres over the canker. On larger trees the canker develops flaring margins with a distinct hump on the side of the trunk opposite the canker (fig. 3, *B*). The wood under the canker is either covered by dead bark or badly decayed and insect-riddled, in contrast to the usually bare, firm wood under Nectria cankers. The Strumella fungus fruits rarely on active cankers, but prolifically on small dead trunks and branches, in the form of raised olive to brown, powdery pustules about one-eighth inch in height and width. Cankered trees are doomed to be culls or become windthrown, and should be discriminated against in improvement operations. Attempts to eradicate this fungus over two large areas in Maryland have not resulted in decreasing subsequent infections as compared with uneradicated areas.

POLYPORUS HISPIDUS CANKER

Oaks above 8 inches in d.b.h. commonly exhibit very irregular trunk cankers several feet long, with thick callus folds on the sides. During the late summer the soft, dark-brown conks of *Polyporus hispidus* can usually be found on these cankers, usually near the top. This fungus is an unusal polypore in that it not only rots wood but also causes extensive cankers. A cankered tree is invariably a cull tree because the fungus always causes extensive heart rot.

HEART ROT FUNGI

A very large number of heart rot fungi cause decay in standing hardwoods. The pines are subject to only two important rots, the pocket rot known as "redheart," caused by *Fomes pini*, and the brown cubical butt rot caused by *Polyporus schweinitzii*. So far as practicable, living trees bearing the conks (fruiting bodies) of heart rot

fungi should be used, felled, or girdled, since these conks shed spores that will infect other trees. Many of the fungi will continue to fruit for some years if the cut trees are left in the woods, but after 5 to 10 years most of them become inactive.

There are some cases where it may be inadvisable to eliminate conky trees. *Fomes rimosus* often appears on practically every black locust in a stand. It would be impractical to try to eliminate it unless the cut trees could be used. Since conks of this fungus may be formed after but little decay, many conky trees are usable for posts. Where sound pine seed trees are scarce on an area needing reseeding, it may be advisable to retain some conky trees as seed sources, at least until the new stand is established.

With a few exceptions, such as in black locust, conky trees are, or soon will be, cull trees. They should be discriminated against in all improvement operations. The job of distinguishing some of the various rot fungus species on hardwoods is difficult. The common ones in any given locality, however, can easily be learned (*22*).

Common or Important Forest Insect Pests in the Appalachian Region[6]

Insects are always present in the forest, and much of the damage they cause goes unnoticed year after year. When certain species become epidemic, large land-using agencies and others become concerned and seek control measures. The insects responsible for such losses are discussed below. For convenience they have been divided into two major groups—those attacking pines and those attacking hardwoods. The economic importance, description of injurious stages, nature of damage caused, and information on the prevention and control of each insect is briefly considered. With the advent of DDT, a new era is approaching in the control of devastating forest insects which affect vast areas. Several methods of distributing this potent insecticide have been developed in addition to the conventional means of application by the use of hydraulic sprayers. One such method consists of the dispersion by airplanes of DDT in an oil solution. A number of large operations, conducted for the control of defoliating forest pests, have proved eminently successful. These results lend encouragement to the idea of controlling forest insects in an epidemic status that heretofore has not been considered economically feasible. However, areas where milk cows and beef cattle are pastured should not be sprayed with DDT.

INSECT ENEMIES OF PINES

The pines suffer from a variety of pests, including the bark beetles, wood borers, twig insects, defoliators, and sucking insects.

The Southern Pine Beetle, *Dendroctonus frontalis* Zimm.

The southern pine beetle in periodic widespread devastations has been responsible for the destruction of more merchantable pine timber

[6] Prepared by C. H. Hoffmann and R. A. St. George, Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine.

in the Southeastern States than any other agent. Reports from commercial and governmental agencies indicate losses of some sixteen million board feet in the Southern Appalachian States from 1922 to 1947.

The adult beetle is brownish or blackish, about 1/8 inch long, cylindrical, with no depression at the posterior end (fig. 22, *A*). It usually attacks the mid-stem portion of a tree first and later the lower trunk, making S-shaped galleries between the bark and wood (fig. 23). Ordinarily small pitch tubes appear along the trunk, and reddish sawdust-like frass is invariably found in bark crevices and at the base of the tree. It may kill groups of a few trees or entire stands covering hundreds of acres. Outbreaks are likely to follow periods of abnormally dry weather. When the drought is broken by rainfall, and conditions favorable for tree growth again prevail, the beetle may

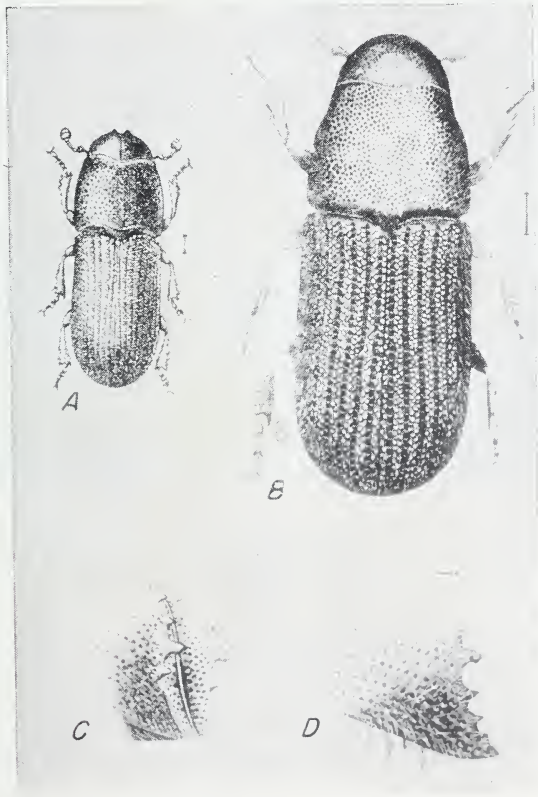

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FIGURE 22.—Adult bark beetles. *A*, The southern pine beetle (note end of abdomen gradually rounded out in a convex manner). *B*, One of the turpentine beetles similar in shape to *A* but larger. *C* and *D*, Parts of *Ips* bark beetles showing posterior end of abdomen scooped out and armed with toothlike projections. The short lines indicate the natural lengths of the beetles. (*B*, *C*, and *D* after Swain.)

EPQ-1727

FIGURE 23.—S-shaped galleries made by adults of the southern pine beetle in the inner, soft bark of pine. Note the oval larval or grub cells about one-fourth to one-half inch on each side of the egg tunnels. Slightly reduced.

almost disappear from the forest. Sometimes outbreaks are checked by lethal low temperatures. Control methods include rapid utilization of infested trees and the burning of slabs containing the brood; felling and limbing infested trees, the trunks of which are then left exposed to direct sunlight; and felling and barking infested trees and burning the bark and tops (*45*).

Another important step in the protection of pine against attack of this insect is that of encouraging the development of mixed stands of pine and hardwoods.

A recent control project conducted in the Great Smoky Mountains National Park indicates the practicability of controlling this insect by using penetrating toxic oils. Infested trees were cut and the trunks

were thoroughly sprayed with 1 part orthodichlorobenzene and 4 parts fuel oil No. 2, which resulted in very effective control. Orthodichlorobenzene is a poisonous substance. Its vapors are poisonous in low concentrations in the air. The same precautions are recommended for handling this compound as are recommended for other chemicals on page 66.

The Engraver Beetles, *Ips* spp.

Following a drought in 1923 and 1924, several species of *Ips* caused a loss of 100 million board feet of southern pines. *Ips* beetles commonly attack dying or recently felled trees but may even kill healthy timber outright, as for instance, when they emerge from slash in which they have bred over a long period and no more dying or felled trees are available for attack. Sporadic outbreaks in which large groups of young saplings and occasionally mature trees are attacked often follow drought, fire, windfalls, and slashings. Since the broods are unable to develop in healthy timber, such outbreaks are short-lived. The beetles carry spores of a fungus with them which penetrates and stains the sapwood.

Ips beetles have a depression at the posterior end of the body, the sides of which are armed with small spines (fig. 22, *C* and *D*). They make straight or star-shaped galleries between the bark and the wood (fig. 24). The three more important species are *I. grandicollis* Eichh., *I. calligraphus* Germ., and *I. avulsus* Eichh. Good forest management practices, including the rapid utilization of blow-down and drought-weakened or littleleaf-diseased timber and the elimination of fire, will be helpful in preventing losses. Under ordinary logging conditions, slash disposal for avoidance of *Ips* attack is not considered necessary (*44*). There is little danger of serious *Ips* attacks in connection with summer woods operations when thinning or logging is done fairly continuously and the weather is not very dry. Sporadic cutting or girdling of the southern pines during the summer, and bark injury such as by long contact with a down tree or piled wood or slash can result in *Ips* attack, especially during dry summers.

The Turpentine Beetles

The red turpentine beetle, *Dendroctonus valens* Lec., and the black turpentine beetle, *Dendroctonus terebrans* (Oliv.), rarely kill trees and are of importance more as a result of the attention they attract than because of the damage inflicted. These beetles are about ¼ inch long (fig. 22, *B*). They attack the bases and roots of practically all species of pine and spruce, causing the exudation of large masses of pitch, commonly called pitch tubes. The larvae may develop in weakened trees around new construction, especially in wounded pines or in stumps. Healthy trees are not killed by their attacks because the beetles are drowned out by the flow of gum.

The Southern Pine Sawyers, *Monochamus scutellatus* (Say) and *M. titillator* (F.)

Adults of these two species of long-horned borers attack dying and recently felled pine trees. The larvae tunnel extensively through

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FIGURE 24.—Work of *Ips avulsus* in bark removed from upper part of tree. Note the comparatively straight adult gallery. About natural size.

the sapwood (fig. 25). After windfalls and burns, sawyers are especially destructive, causing rapid deterioration of timber particularly during midsummer, often before it can be salvaged. The adults are readily recognized by their long antennae. The females make large pits in the bark through which the eggs are deposited in the inner bark. Trees showing many of these pits should be marked for removal, because attack by this insect is a definite indication that the tree will die. These round-headed borers are ravenous feeders and push quantities of shredded frass to the exterior. When abundant, their gnawing is audible at a considerable distance from the tree. Sometimes the adults cause minor injury to trees through their feeding on the bark and wood of twigs. To prevent losses from sawyers, all recently cut and infested material should be utilized as promptly as possible.

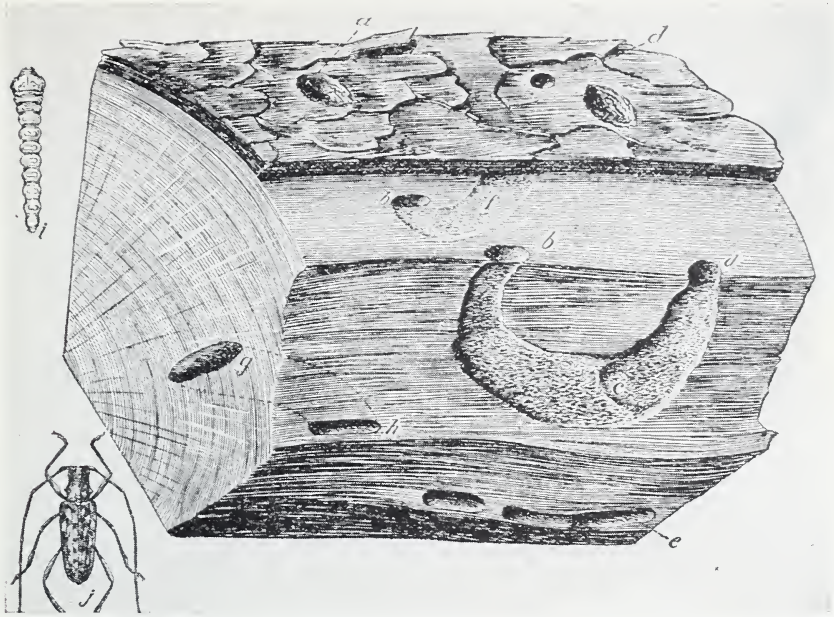

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FIGURE 25.—Work of the southern pine sawyer. Section of trunk showing: *a*, Egg pit in bark; *b*, Entrance hole of larva into wood; *c*, Pupal cell; *d*, Emergence hole; *e*, *g*, *h*, Sections of larval mines; *f*, Scored surface of wood, scoring done by larva preparatory to entering wood; *i*, Larva; *j*, Adult. Insect one-half natural size. (Webb.)

The White Pine Weevil, *Pissodes strobi* (Peck)

This weevil is of minor importance in the Southeastern States. Adult female weevils, which are characterized by a prominent snout, lay eggs in the leading white pine shoots of the previous season. The larvae are voracious feeders and soon girdle the shoots by feeding on the phloem tissues. Killing of the leader results in loss of height and malformation. The timber value is materially affected because of large knots and crooks in the stems. Direct control measures are generally too expensive for common use. However, in the near future, such control may be feasible with the use of DDT. In pure stands, the greater the number of trees per acre, the smaller will be the percentage of weevil infestation. Such dense stands are economically practical only when they can be reproduced naturally at a density high enough to withstand any severe infestation which may occur (*31*). The most advantageous way to protect white pine from severe injury is to grow it in mixture with hardwoods, particularly where the pines are partially suppressed by the hardwoods, and preferably with species that will be of value in the final crop.

The Nantucket Pine Tip Moth, *Rhyacionia frustrana* (Comst.)

Tip moths are common and serious pests of young pines, particularly of loblolly and shortleaf seedlings and young saplings. Periodi-

cally they become of great importance locally. The small yellowish larvae, which become nearly one-half inch in length, mine at first in the needles, then the buds, and finally down the centers of the twigs. They spin a delicate web enclosing the buds and surrounding needles, and always work on the new growth at the terminals of the branches, killing them. About 16 different parasites help to hold the Nantucket tip moth in check. No satisfactory control method has yet been devised, although limited tests conducted recently indicate DDT emulsions may be effective. A certain measure of control may be obtained by removing and destroying the infested tips in small plantings.

The Red-headed Pine Sawfly, *Neodiprion lecontei* (Fitch)

This sawfly is a widely distributed species that attacks young pines. The eggs are laid in slits in the needles. Mature larvae are easily distinguished because they are yellowish-white with several rows of black spots on the body, and the head is reddish-orange to dark brown. They feed in groups and devour both the old and new needles. They also eat patches of bark from the twigs, with the result that individual branches often die. Occasionally the trees infested are completely defoliated and as a result are killed or severely stunted. Outbreaks occur periodically and there may be two or more broods per year. This, as well as most other species of sawflies, may be effectively controlled by spraying infested trees with arsenate of lead at the rate of 3 pounds to 100 gallons of water. Lead arsenate is a poisonous compound. It is not flammable, otherwise the same precautions are recommended for its use as for other chemicals on page 17. Recent experimental work has shown that sawflies can be controlled by a DDT in oil spray dispersed from airplanes. Areas used for pastures should not be sprayed with DDT or lead arsenate.

A Scale Insect, *Matsucoccus gallicolla* Morrison

During the past 10 years this scale insect has been found associated with killed twigs of southern pines and with stunted terminals and off-color foliage. During the growing season this species is evident in small pustule galls on the young twigs of the host pines. A close examination of the gall usually indicates a small opening beneath which may be found the baglike scale insect. The injuries are usually sporadic and often involve so few trees that control measures are unnecessary. Any chemical control applied would have to be directed at the young exposed crawlers.

The Pine Bark Aphid, *Pineus strobi* (Htg.)

The presence of this very common chermid is indicated by spots and patches of white cottony material on the trunks and the underside of the limbs of white pine. A difference of opinion exists regarding its economic importance. Some observers maintain that the myriads of nymphs result in reduced growth and the yellowing of the needles and that, in the case of severe infestation, there is a loss of limbs. Other observers are inclined to believe that the chermids and aphids cause little damage. An increasing number of infestations have been

observed recently, and it appears probable that several species of *Pineus* are involved in the deterioration of young white pines. They may be the cause of death of terminals of pines up to 20 feet in height and occasionally are the cause of the loss of the lower branches of larger trees. One species, *Pineus pinifoliae* (Fitch) has been closely associated with such injury. Aphids and chermids may be controlled with an oil emulsion or a miscible oil to which is added nicotine sulphate at the rate of 1 pint to 100 gallons of water. Nicotine sulphate is a poisonous compound, particularly in its undiluted state. Where extensive spraying operations are necessary, operators should wear full facepiece respirator and skin covering in order to avoid ingesting the spray in any way, as the effects are cumulative. Thoroughly clean vessels used in mixing and spraying operations before storing. Thoroughly clean all clothing worn during the operations before storing or further use.

INSECT ENEMIES OF HARDWOODS

The Hickory Bark Beetle, *Scolytus quadrispinosus* Say

This beetle is an important enemy of several kinds of hickories. Every few years local outbreaks occur which can be correlated with drought, fire, lightning, or other agents that weaken the trees. The beetle is small, dark brown in color, and about one-fifth inch in length. Each female cuts an egg channel between the inner bark and sapwood, parallel with the tree axis, and deposits eggs in tiny niches along each side. The grubs bore out at right angles and finally pupate at the ends of the larval tunnels. In this way the larvae completely girdle the larger branches and the trunk of the tree. Fortunately, the beetle is held in check by many parasites and by high rainfall. Injury caused by the hickory bark beetle to weakened trees cannot be prevented except by adopting such forest management practices as will keep the trees in a sound and vigorous condition.

The Locust Borer, *Megalcyllene robiniae* (Forst.)

This insect inhibits the production of good-sized black locust. It attacks saplings up to pole size grown in the open without adequate protection of shade. The adult is from one-half to three-quarter inch in length and of a dull black color, brightly marked with yellow lines on the thorax and wing covers. At the base of the elytra there is a conspicuous W-shaped marking. The white cylindrical round-headed larva is nearly 1 inch in length. The larvae make large tunnels in the sapwood and heartwood, rendering the trees subject to wind breakage and attack by *Fomes rimosus*. A close relationship exists between damage and tree vigor.

Several silvicultural methods show promise in borer control. Clear-cutting appears useful in slow-growing stands where cutting of the trees is followed by very rapid growth of the sprouts which develop from the stumps. Thinning of rapidly growing stands, where the more slowly growing and highly susceptible understory trees are removed, reduces the borer population and makes conditions for growth more favorable in the residual stand by reducing competition.

Damage may also be reduced by growing black locust on well-adapted sites and by keeping the stands fully stocked so that the boles of the trees are shaded. For the control of small larvae beneath the bark, orthodichlorobenzene emulsion is a promising spray material but is ordinarily too expensive to apply over large areas (see caution on use, page 66). In small plantations, spray applications of 5-percent DDT emulsions to the tree trunks kill large numbers of beetles and prevent oviposition. The DDT emulsion should not be used in areas where milk cows and beef cattle are pastured.

Additional experimental work may indicate the desirability of spraying DDT from airplanes at the time the adults are feeding on the flowers of goldenrod.

The Columbian Timber Beetle, *Corthylus columbianus* Hopk.

Adults of this ambrosia beetle attack living white oak, yellow-poplar, birch, beech, and sweetgum, entering directly through sound bark. In some areas from 15 to 25 percent of the white oak trees may be affected and, where tight barrel staves are being manufactured, mature trees are being discarded because of injury by this insect. Buyers of trees to be used for furniture manufacture frequently abandon operations when they find that the wood is too wormy for their use. The pinholes caused by this ambrosia beetle are about one-twelfth inch in diameter, open, and always accompanied by discolored streaks in the surrounding wood (*48*). Control consists of the removal and destruction of heavily infested brood trees whenever they are found in a forest.

Other Ambrosia Beetles

The predilection of certain species of ambrosia beetles for freshly killed or dying trees often affords a practical guide for estimating the effects of forest fires and the marking of trees for removal in fire-damaged stands. These insects are the ones which attack the earliest and in the greatest numbers. They are elongate, cylindrical, brownish-black beetles with the posterior end of their body rounded and not depressed. They vary from one-eighth to one-quarter inch in length. Two genera commonly found associated are *Platypus* and *Xyleborus*. Their attack is easily recognizable by the presence of small pinholes extending into the wood, from which often protrude short tubular columns of white frass. Such frass may be noticed in the bark crevices or in piles around the base of the tree. These beetles attack only moist dead wood, and, when their tunnels are found associated with fire injury, it is a sure sign that the part of the tree in which their galleries are present has been killed. When their entrance holes are present completely around the base of the trees, such trees should be marked for removal.

The Oaktimber Worm, *Arrhenodes minutus* Drury

This is a common timberworm that enters through wounds and also attacks the wood of living trees and produces defects in the lumber. The larvae make worm holes one one-hundredth to one-eighth inch in

diameter in white, northern red, and chestnut oaks. The holes extend in all directions through the heartwood of mature and overmature trees and frequently are so abundant as to cause entire trees to be rejected on account of the defects. These losses cannot be prevented when occurring in living trees, but they can be lessened somewhat by the removal and destruction of dead and dying snags and badly fire-scarred trees.

The Two-lined Chestnut Borer, *Agrilus bilineatus* (Weber)

This borer appears to be a secondary pest of oaks, particularly of those species in the black oak group. The flat-headed larvae mine throughout the cambium of infested trees and, when numerous, completely girdle the trunk and branches. The larval tunnels run obliquely at first and later nearly transversely around the trees. Ordinarily this species does not seem to be of much importance unless the trees have been previously weakened by drought, fungi, or some other agent. When heavily infested trees are discovered, they should be cut and utilized, and the slabs containing the borer destroyed by burning unless debarked.

The Locust Leaf Miner, *Chalepus dorsalis* Thunb.

Widespread defoliation of black locust and some other trees is caused by this leaf miner. The skeletonizing causes the leaves of the trees to turn brown late in the summer. The amount of actual injury to the trees is probably slight because most of the feeding occurs late in the season. The adult is a wedge-shaped beetle, about one-quarter inch long. The edge and middle of the wing covers are black, whereas the remainder is mostly bright orange red. The larvae live together for a short time and thereafter each one mines and occupies a separate leaf. The pest is easily controlled with arsenate of lead, 3 or 4 pounds to 100 gallons of water or with a 2-percent DDT emulsion. The precautions recommended on pages 17 and 66 should be followed.

Other Defoliators

Periodically a number of other defoliating insects become destructive in the forest. If defoliation occurs for only one or two seasons, the loss is not very great, but ordinarily these outbreaks last for several years and undoubtedly weaken many trees and cause the death of others. Some of the more important defoliators include the spring cankerworm, *Paleacrita vernata* (Peck); the fall cankerworm, *Alsophila pometaria* (Harr.); the forest tent caterpillar, *Malacosoma disstria* Hbn.; the eastern tent caterpillar, *Malacosoma americanum* (F.); the fall webworm, *Hyphantria cunea* (Drury); the orange-striped oakworm, *Anisota senatoria* (A. & S.); and the variable oak leaf caterpillar, *Heterocampa manteo* (Dbldy.). The larvae of all these species cause damage by destroying the foliage. All of them may be controlled by spraying, using either arsenate of lead at the rate of 3 pounds to 100 gallons of water with 12 ounces of fish oil or linseed oil added as a sticker, or DDT as an emulsion or a wettable powder at the rate of 1 pound of the technical powder per 100 gallons of water. The direct

use of chemical control has seldom been feasible over forested areas in past years, but it now appears likely that the aerial application of DDT as an oil solution will prove to be a practical means of controlling these pests in future years.

Specifications for Grading "Premium" Nursery Stock

	Red spruce	*Red pine*
Grading characteristic:		
Stem diameter (inches)		
Minimum	0.15	0.20
Average	0.20	0.25
Ratio of root mass to crown mass:[1]		
Minimum	0.6 to 1	0.4 to 1
Average	0.7 to 1	0.5 to 1
Ratio of crown length to stem length:[2]		
Minimum	2 to 1	1 to 1
Average	3 to 1	1.75 to 1

[1] Root and crown mass were determined on a green weight basis.

[2] Crown length refers to that portion of the stem covered by needles; stem length is the bare portion of the stem.

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